BUREAU OF FISHERIES

REPORT OF

THE COMMISSIONER OF FISHERIES FOR THE FISCAL YEAR 1911

AND

SPECIAL PAPERS

GEORGE M. BOWERS
Commissioner

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REPORT OF THE COMMISSIONER OF FISHERIES FOR THE FISCAL YEAR ENDED JUNE 30, 1911

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REPORT

OF THE

COMMISSIONER OF FISHERIES.

Department of Commerce and Labor,
Bureau of Fisheries,
Washington, December 26, 1911.

Sir: I have the honor to submit herewith a report of the operations of the Bureau of Fisheries for the fiscal year ended June 30, 1911.

PROPAGATION OF FISHES.

GENERAL REVIEW OF THE WORK.

The fish-cultural operations of the Bureau, consisting of the propagation and distribution of fishes for public and private waters in the interior sections of the country and of the lobster and important marine fishes to replenish the waters along the north Atlantic seaboard did not vary materially from those of preceding years. The efforts were directed chiefly toward the development of present resources and the increase of the output by the extension of operations over a wider territory in fields contiguous to existing stations.

The possibilities for fish-cultural work are practically unlimited, being gauged only by the funds and experienced men available for opening up new fields. This is particularly true with reference to the Pacific coast salmons, the trouts of the Rocky Mountain region, the commercial fishes of the Great Lakes, and the anadromous and marine species of the Atlantic coast. With the basses, sunfishes, and catfishes, whose eggs can not be handled artificially and which are propagated under natural conditions in ponds, a more thorough understanding of the requirements of food supply and environment has carried this work also beyond the experimental stage and to equal possibilities of cultivation.

One new station was added to the service with the completion of the plant at Homer, Minn., where fish-cultural work was inaugurated at the beginning of the year. The stations operated numbered in all 36 permanent and 90 auxiliary and collecting stations, located in 33 States. At these stations upward of 40 species of food and game fishes were handled.

Fish-cultural operations at the various stations are governed largely by meteorological conditions; floods, droughts, storms, and abnormal water temperatures in the spawning season hamper the work and necessarily cause variations in the egg collections from year to year, regardless of carefully executed plans. While adverse weather curtailed the egg-take of important species in some sections, substantial gains were made in other fields, and the outcome of the year's work was the largest output of fish and eggs in the history of the Bureau, the total being 3,646,294,535, or 12.83 per cent greater than in 1910. This favorable showing is largely accounted for by the adoption of new methods and the utilization of improved appliances, resulting in increased efficiency and diminished expense.

The year's distributions of fish to public and private waters involved railroad travel approximating 100,915 miles by the Bureau's cars and 319,819 miles by detached messengers. The amount of free transportation allowed was a little over one-sixth of the number of miles traveled.

The following table summarizes the distribution of fish and eggs for the year:

SUMMARIZED STATEMENT OF DISTRIBUTION OF FISH AND EGGS, FISCAL YEAR 1911.

Species.	Eggs.	Fry.	Fingerlings, yearlings, and adults.	Total.
Catfish			358,540	358,540
Carp			1,425	1,425
Buffalofish		1,200,000	233,514	1,433,514
Shad		91,521,000		91,521,000
Whitefish	61,010,000	301,563,750		362,573,750
Lake herring		4,600,000		4,600,000
Silver salmon	2,391,900	6,216,096		8,607,996
Chinook salmon	37,314,514	16,739,804	322,360	54,376,678
Blueback salmon	1,500,000	100,490,900		101,990,900
Humpback salmon		460,150		460,150
Dog salmon		69,000		69,000
Steelhead trout	660,000	3,870,794	63,875	4,594,669
Rainbow trout	1,202,100	915,660	1,881,553	3,999,313
Atlantic salmon		2,854,084	23,000	2,877,084
Landlocked salmon	331,000	234,221	177,683	742,904
Blackspotted trout	1,496,000	420,026	3,107,500	5,023,526
Loch Leven trout			68,125	68,125
Lake trout	6,587,500	18,801,950	1,931,500	27,320,950
Brook trout	455,500	6,793,545	5,341,607	12,590,652
Sunapee trout	10,000	79,685	10	89,695
Grayling	155,000	1,842,670		1,997,670
Crappie and strawberry bass			147,269	147,269
Rock bass			82,941	82,941
Warmouth bass			200	200
Smallmouth black bass		614,000	102,537	716,537
Largemouth black bass		8,000	497,592	505,592
Sunfish (bream)			470,667	470,667
Pike perch	424,000,000	278,030,000		702,030,000
Yellow perch	6,200,000	434,691,150	11,116	440,902,266
Striped bass		1,318,000		1,318,000
White perch	15,000,000	427,177,500		442,177,500
Yellow bass			2,451	2,451
Scup		568,000		568,000
Cod		179,311,000		179,311,000
Pollock		114,230,000		114,230,000
Haddock		19,139,000		19,139,000
Flatfish		888,763,000		888,763,000
Lobster		170,631,000	1,571	170,632,571
Total	558,313,514	3,073,153,985	14,827,036	3,646,294,535

Of these distributions 550,470,414 eggs, 1,029,800 fry, and 1,060 larger fish were delivered to various State fish commissions, and 86,000 eggs, 6,000,000 fry, and 2,050 older fish were furnished for shipment to foreign countries. These transactions are shown in detail in the accompanying statements:

ALLOTMENTS OF FISH AND EGGS TO STATE FISH COMMISSIONS, FISCAL YEAR 1911.

States and species.	Eggs.	Fry.	Finger-lings.
California:			
Chinook salmon	32,952,514		
Silver salmon	2,289,900		
Colorado:			
Blackspotted trout	200,000		
Connecticut:			
Yellow perch	5,200,000		
White perch	15,000,000		
Pike perch	2,000,000		
Illinois:			
Pike perch	8,000,000		
Lake trout	100,000		
Crappie			40
Sunfish (bream)			250
Yellow perch			20
Maine:			
Landlocked salmon	200,000		
Massachusetts:			
Chinook salmon		10,000	
White perch		1,000,000	
Michigan:			
Whitefish	10,000,000		
Pike perch	50,000,000		
Lake trout	4,000,000		
Landlocked salmon	25,000		
Minnesota:			
Steelhead trout	100,000		
Lake trout	200,000		
Landlocked salmon	25,000		
Chinook salmon		10,000	
Missouri:			
Rainbow trout	25,000		
Brook trout	25,000		
Pike perch	3,000,000		
Grayling	50,000		
Montana:			
Whitefish	500,000		
Nebraska:			
Rainbow trout	50,000		
Nevada:			
Rainbow trout	25,000		
Brook trout	75,000		
Blackspotted trout	235,000		
New Hampshire:			
Chinook salmon	50,000		
New York:			
Lake trout	100,000		
North Dakota:			
Steelhead trout	200,000		
Pike perch	19,500,000		
Blackspotted trout	50,000		
Ohio:			
Pike perch	187,775,000		
Oregon:			
Chinook salmon	3,950,000		
Blueback salmon	1,500,000		
Blackspotted trout	273,000		
Pennsylvania:			
Whitefish	44,000,000		
Pike perch	151,725,000		
Silver salmon	100,000		
Rhode Island:			
Landlocked salmon	20,000		
Utah:			
Rainbow trout	100,000		
Steelhead trout	50,000		

ALLOTMENTS OF FISH AND EGGS, ETC.—Continued.

States and species.	Eggs.	Fry.	Fingerlings.
Vermont:			
Chinook salmon	50,000		750
Silver salmon		5,800	
Lake trout	100,000		
Landlocked salmon	20,000		
Wisconsin:			
Whitefish	4,000,000		
Lake trout	2,000,000		
Wyoming:			
Rainbow trout	50,000	4,000	
Steelhead trout	60,000		
Blackspotted trout	445,000		
Grayling	50,000		
Lake trout	25,000		
Total	550,470,414	1,029,800	1,060

SHIPMENTS OF FISH AND EGGS TO FOREIGN COUNTRIES, FISCAL YEAR 1911.

Country.	Species.	Eggs.	Fry.	Fingerlings, yearlings, and adults.
Brazil	Smallmouth black bass			1,000
Canada	Pike perch		6,000,000	
Cuba	Rainbow trout			1,050
Germany	do	50,000		
Portugal	do	36,000		
Total		86,000	6,000,000	2,050

Notwithstanding the heavy increases in output shown from year to year, it has been impossible to keep pace with the needs of public and private waters. The rapidly increasing population and consequent opening up of new territory, the changed physical conditions of the country, continuous expansion of the fisheries, lax enforcement of fishery laws by many States, and total disregard of fishery interests by others—all of these causes combine to render imperative the greatest possible exertions on the part of the Bureau.

The benefits accruing from the Bureau's efforts are manifested through the widespread interest in the work by people in all sections of the country. The applications for food and game fishes received during the year numbered 10,393, and over half of them were for the black basses, crappies, sunfishes, and catfishes, for stocking artificial ponds on farms. The popularity of this branch of the work is constantly increasing with the fuller realization that the maintenance of private fishponds can be made a valuable adjunct of farming, as a food supply for home consumption, and as a source of revenue.

The species propagated in larger numbers in 1911 than in 1910 included the chinook salmon, steelhead trout, brook trout, rainbow trout, grayling, pike perch, yellow perch, white perch, smallmouth black bass, buffalofish, pollock, haddock, and lobster. The output of Atlantic salmon was double that of any previous year.

A marked falling off is shown in the output of blueback salmon at the Afognak (Alaska) station, due to the unaccountably small run of fish in streams tributary to Litnik Lake. Fish-cultural operations in connection with this station were undertaken at Malena Lake, heretofore regarded as a field of sufficient productiveness to warrant the establishment there of an auxiliary station, but the total collections of eggs at both places amounted to only half the take of the preceding year at the main station alone.

At the Yes Bay (Alaska) station, on the other hand, more favorable weather conditions resulted in a large run of blueback salmon. The hatchery was filled to its capacity with eggs, and a sufficient number of fish to have produced fully 10,000,000 more were allowed to escape because of lack of facilities for handling them.

There was a slight decrease in the output of some of the species handled at the Pacific coast stations, but the work in general was satisfactory. An average run of chinook salmon occurred in the Sacramento River, but low-water stages in tributary streams prevented many of the fish from reaching their customary spawning grounds and large numbers of eggs were deposited in the main river. Later in the season freshets carried away the retaining racks, permitting the escape of many impounded fish and the loss of millions of eggs. Despite these unfavorable occurrences the take of eggs at Baird and its auxiliaries was nearly 5,000,000 in excess of that of the previous year, most of the gain being at Battle Creek.

Two new field stations were established in California and operated in connection with the Baird station during the year—one at Klamathon for chinook and silver salmon, and the other at Hornbrook for rainbow trout. At the Klamathon station, in the construction of which the State fish commission bore half the expense, the racks were not completed in time to intercept the run of chinook salmon. Later in the season, before the completion of the silver salmon work, they were carried away, but not before satisfactory collections of eggs had been made. At Hornbrook the take of rainbow trout eggs far exceeded the expectations, being in excess of 2,000,000.

The conditions affecting the run and shortening the spawning season of the salmon in California prevailed also in the Columbia River and its tributaries, but as a whole the work of the Oregon stations was successful, the falling off in chinook salmon being offset by substantial gains in the output of silver salmon and steelhead trout. At the Big White Salmon station the experiment of penning chinook salmon and holding them for the ripening of their eggs was conducted in a small way with results that warrant a more extensive trial in future, this apparently being the easiest and most economical method of collecting eggs in this region. The fish are procured from trap fishermen in the vicinity at a cost of 12½ cents each and towed

in live cars to retaining pools. Being ripe or nearly so, the fish are not suitable for canning or shipment and have heretofore been sold only to the Indians. Toward the close of last year's run of salmon at this point an average of two tons of fish per day were being taken in the traps.

There were the usual runs of chinook, silver, and blueback salmon in the Skagit River, Wash., but low water prevented many of them from ascending to the spawning grounds. As a consequence there was a slight decrease in the output of fry of these species. More favorable conditions were experienced in connection with the steelhead trout work, and the collection of eggs was the largest made since the establishment of the Baker Lake station. The installation of a new trap of an improved plan is the medium which is expected to result in greatly increased collections of steelhead trout eggs another year.

The trout work on Lake Michigan and Lake Huron was seriously curtailed, partly by storms, which prevented the fishermen from raising their nets, but primarily by the State fishery law. Handicapped by unfriendly restrictive legislation, the Bureau can not hope to attain results commensurate with its efforts.

Notwithstanding the large catches of whitefish by fishermen operating in Lake Erie in the vicinity of Monroe Pier, Mich., and along the Canadian shore at the mouth of the Detroit River, few fish ascended that stream as compared with the enormous runs recorded in former years. In view of the continued decline in the whitefish fishery in the Detroit River, the contemplated construction of a ship canal in proximity to the fishery off Grassy Island, and the consequent abandonment of the station at that point, it is doubted if future results will justify the continuance of operations here. With the view of extending the work over a larger territory and locating in a more productive field, steps were taken to secure from the Bureau of Lighthouses the fishing privileges in waters coming within the Government's jurisdiction in the vicinity of Big Charity Island in the Saginaw Bay district of Lake Huron, with authority to establish and operate a field-collecting station on that island. The construction of this station is now in progress, and it is believed its operation another year will enable the Bureau greatly to increase the output of whitefish in Michigan waters.

The whitefish work at the Lake Erie station was encouraging. Not only were more eggs taken than last year but the percentage hatched was larger than usual, owing to favorable water temperatures in the spawning season. The bulk of the eggs were derived from penned fish, the gill-net fishermen furnishing only a small proportion as compared with previous years.

Unfavorable weather in the fields operated from the Duluth station, coupled with the inferior quality of the eggs taken by inexperienced men in Michigan waters, caused a shortage in the lake trout work at this station.

The pike-perch operations on the Great Lakes and at Swanton, Vt., were highly gratifying, the number of fry distributed being over 226,000,000 in excess of the output of this species last year. The largest increase occurred at the Lake Erie station, where the egg collections amounted to nearly 800,000,000. There was also an increased output from the stations at Detroit, Mich., and at Swanton, Vt., the amount of increase over the preceding year being 93 per cent and 33.3 per cent, respectively. Part of the eggs hatched at the Michigan station were purchased from fishermen operating near Port Lambton, Ontario.

The collection of pike-perch eggs on Lake Ontario was undertaken this year for the first time at a field station operated in connection with the Cape Vincent station. While storms and floating ice greatly interfered with the work of the commercial fishermen, over 16,000,000 eggs were secured, which indicates that pike perch are increasing in Lake Ontario as a result of the Bureau's work at the Cape Vincent station. This is also the unanimous opinion of fishermen operating in that territory.

The Atlantic salmon operations at the Craig Brook (Me.) station were entirely satisfactory, the output of this species for the year numbering 2,877,084, which shows an increase of 50 per cent over the preceding year, and indicates a gratifying growth in the salmon run of the Penobscot River as a result of the Bureau's propagation of this species. Encouraged by this excellent showing, arrangements are being made to extend the work on the upper Penobscot another year.

Unfavorable weather conditions interfered with the marine work to such an extent as to cause a serious falling off in the cod and flatfish output, but owing to the highly gratifying outcome of lobster operations at the Boothbay Harbor (Me.) station, the combined product of marine species exceeded that of the previous year by over 17,000,000. The pound at this station is now in first-class condition, and the experience gained in the past has led to greatly improved methods in handling the brood stock during the winter months. Not only were the lobsters in better condition when removed in the spring, but the percentage of eggs secured was larger than in any previous year, and their quality was superior.

Comparative success was attained this year for the first time in the propagation of the haddock at the Boothbay Harbor station, the production of fry amounting in round numbers to 19,000,000, as against 712,000 the previous year. Heretofore it has been impossible

with the available facilities to transfer the eggs from the fishing grounds to the station, owing to the necessity of maintaining an equable temperature, but with improved steamer service and more suitable equipment this difficulty has apparently been overcome.

Owing to changed fishing methods around Gloucester (Mass.) the collection of pollock eggs in 1911 was the largest ever secured for that station. Until 1909 pollock fishing was conducted almost wholly with hand lines operated from sailing vessels, but of late motor boats fitted out with gill nets and several large steam netters have taken up the work. From this source more fish were obtained than could be handled to advantage with the force of spawntakers available.

With the view of artificially propagating the menhaden, investigations were conducted at the Woods Hole station, but no material results were obtained owing to inability to secure ripe fish of both sexes at the same time. As fish with nearly ripe spawn have been taken in considerable numbers both in spring and fall, it seems clear that the menhaden has two spawning periods, the first occurring in the brackish coastal waters northward, and the second in the open sea southward.

Notwithstanding the large catches of shad reported in Chesapeake Bay, there was a shortage in the egg collections and in the output of fry at the stations on the Potomac and Susquehanna Rivers. Stormy weather and unfavorable water temperatures at both stations affected the run of fish to some extent, but the principal obstacle was the failure of a fair percentage of fish to pass the cordon of pound and other nets operated in the bay and near the mouths of these rivers. The successful operation of suitable local laws in the Albemarle Sound region has enabled the Bureau yearly to increase the output of shad from the Edenton (N. C.) station, the distribution of fry in 1911 surpassing that of any previous year. The clause of the regulations in force in 1910, which prohibited the fishing of gill nets within 800 yards of a pound net, was this year changed to 400 yards, thus affording gillers fishing in the Bureau's interest a wider field of operations.

The white perch and yellow perch operations on the Susquehanna River resulted in a substantial increase in the output of both species at the Havre de Grace (Md.) station. At the Bryans Point (Md.) station on the Potomac River more yellow-perch eggs were obtained than could be handled in the jars available, and the remainder were successfully hatched in specially constructed cylindrical wire baskets suspended in the river on stakes. The total output of white perch and yellow perch exceeded that of any previous year.

The artificial hatching of striped bass was conducted in the usual way at the Weldon (N. C.) station, but the hindrances heretofore encountered were again in force and rendered the work almost inef-

fective. Freshets early in the spawning season, followed later by low stages of clear water, inability to secure both sexes in spawning condition in sufficient numbers at one time, were some of the difficulties, but the chief obstacle to success, as with the shad, is the lack of legislation to insure the ascent of a fair percentage of fish to the spawning grounds. In view of repeated failures to propagate this species in considerable numbers, it appears inadvisable to continue the work.

The propagation of the striped bass in California has been suspended on account of recently enacted legislation prohibiting the capture of the fish by commercial fishermen. The enforcement of this law leaves the Bureau no recourse except to conduct fishing operations on its own account, and the expense of such a proceeding makes it impracticable.

The output of brook trout at the various stations is regulated largely by the stock of eggs purchased from commercial dealers, this course in the majority of instances having proved more economical than dependence upon local waters for egg collections. At stations located in productive fields, where the collection of wild eggs from local sources justifies the expense, the results have been gratifying. This is especially true as regards the operations in Colorado.

Blackspotted trout operations were again undertaken on the Truckee River at Derby Dam, Nev., but owing to a small run of fish early in the season and the difficulty of capturing them in the swift currents—accomplished by means of dip nets from a platform on the bank—there was a decided falling off in the egg collections as compared with the previous year. A second run of fish appeared late in May, but the high water made it impossible to resume operations. As a suitable water supply could not be secured in the vicinity of the field operated in 1910, the station was moved to a location near Sparks, Nev., where water from a spring is available. It seems advisable to continue the work next season, as the indications are that from 4,000,000 to 5,000,000 eggs may be secured in a normal season.

The Yellowstone Park station, which has heretofore been operated under the direction of the superintendent of the Spearfish (S. Dak.) station, was this year placed in charge of the superintendent of the Bozeman (Mont.) station. The object of making the change was to secure a more economical administration of the station, which is in the immediate vicinity of Bozeman. The collection of eggs in this field was not undertaken until late in June, because of the late spawning season and impassable roads; therefore the number reported on July 1 was slightly below that of last year at the same date. The indications at that time were, however, that the season's total would be larger than that of any previous year.

With the absence of the usual spring freshets in the upper Mississippi River, and the unprecedently low water stages which made navigation impossible, no rescue operations could be undertaken at the field stations operated in connection with the Manchester station. Conditions on the Illinois River were more favorable, and large collections of black bass, crappie, sunfish, and catfish were made from overflow waters and furnished for distribution. The output materially exceeded that of the previous year.

At the Helena (Ark.) and Rosedale (Miss.) stations, the latter operated for the first time in 1911, the number of fish furnished for distribution was small, but large numbers were transferred from the levee pits to the open waters of the river, and this is regarded as one of the most important features of the work.

In October a carload shipment of lobsters and oysters, previously assembled at the Boothbay Harbor station, was made to the Pacific coast. The consignment, consisting of 15 barrels of oysters and 1,940 lobsters, nearly two-thirds of them females, arrived at Seattle in excellent condition, notwithstanding the warm weather encountered en route. Fully 75 per cent of the lobsters were lost, however, owing to the necessity of towing them a full day's journey on an open scow in an incessant rain in order to reach Port Ludlow, in Puget Sound, where the survivors were liberated. Sentiment in favor of the Bureau's efforts toward the acclimatization of the lobster in Pacific coast waters is evidenced by the recent enactment by the Oregon Legislature of a law prohibiting lobster fishing in the waters of that State for a period of five years.

SPECIAL FEATURES OF THE FISH-CULTURAL WORK.

West coast salmon.—The superintendent of the California stations again calls attention to the enormous destruction of young salmon in the Sacramento River through the medium of irrigation canals and the attacks of black bass during the migration of the salmon to salt water. One of the canals referred to is 85 feet wide at the bottom, and as the fry follow the current in their descent of the river large numbers are carried into the canal by the inflowing water and are left stranded on adjacent lands. It is understood the construction of other dams is contemplated in the near future, and unless the fry are planted below the intake or some effective method of screening is resorted to it will be impossible to maintain the present run of salmon in the Sacramento River. The true solution of the problem would be the erection of a hatchery sufficiently large to accommodate all chinook eggs collected at the Baird, Mill Creek, and Battle Creek stations at some desirable point below the intake of the irrigation canals and where the fry would not be subjected to the attacks of predatory fishes.

The California Fish Commission, realizing the futility of maintaining the supply of salmon in the Sacramento and tributaries in the face of such adverse conditions, is contemplating the establishment of a hatchery near tide water for the development of eggs collected at interior stations. It is a matter of much importance that the Bureau make provision to do likewise in the near future.

In view of the importance of the salmon fisheries of the Pacific States and their apparent decline in certain regions, renewed efforts should be made by the Bureau to increase the output of its stations. With the establishment of the new Puget Sound stations, two of which are now nearing completion, the State of Washington will be well provided for. In Oregon and California the best results can be accomplished by extending operations over a wider territory through the establishment of inexpensive field stations at points where eggs can be collected in considerable numbers and shipped to a central station for development. Good results are now being attained in the operation of a number of such stations and it is recommended that the work be extended another year.

Cultivation of buffalofish.—Further experiments were conducted during the year at the Homer (Minn.) station and at an auxiliary of the Manchester (Iowa) station in an effort to propagate various species of the warm-water fishes indigenous to the upper Mississippi River by the artificial manipulation of their eggs, but owing to unfavorable water stages in the river very few fish were taken by the commercial fishermen and difficulty was experienced in securing them in spawning condition. Successful results were, however, attained with the buffalofish. From three females of this species 3,500,000 eggs were taken, water-hardened in floating boxes in the river, shipped by express to Manchester on canton-flannel trays in well-iced boxes with moss packing, and hatched in jars somewhat similar to those used for pike-perch eggs. Unlike the eggs of the pike perch, however, they are not adhesive and require no muck, starch, or mechanical motion to prevent bunching. After hardening the eggs measure 14 to the linear inch, showing an increase of about 50 per cent in bulk. One distinct characteristic of the fry is their inactivity. They did not pass out of the jars after hatching and some which were transferred to troughs lay dormant on the bottom. The best results were secured with those retained in jars.

From a commercial standpoint, the buffalofish is regarded as one of the most valuable food species of the Mississippi and Illinois Rivers, and it has apparently decreased in numbers in recent years. Its propagation on an extened scale is therefore advisable. Under normal conditions and with an ordinary catch of fish, the take of eggs in these rivers will probably amount to hundreds of millions, and it is believed the hatch will average 50 per cent.

Attempt to hatch lake sturgeon.—With the view of obtaining some authentic information regarding the feasibility of hatching sturgeon in the Lake of the Woods and its tributaries in Minnesota and Canada, an experimental field station was established in the spring of 1911 on the shore of that lake at Le Claire Point, Minn., near the mouth of the Rainy River, the work being under the direction of the superintendent of the Duluth (Minn.) station. A small temporary hatchery capable of accommodating 1,500,000 eggs was installed at a commercial fishery, and a pound in which to retain the spawning fish was constructed in the open lake in the vicinity.

Acting upon the supposition that the most desirable specimens of sturgeon for experimental work could be secured from the small number of fish ascending the river early in May, a pound net was set in such a manner as almost entirely to stop the ascent of sturgeon through the channel on the American side, and between May 6 and June 14 six mature and 10 immature sturgeon were secured and impounded without injury. Seven very large sturgeon which had been caught in pound nets in the open lake were also held in the pound from 10 to 30 days without injury. All ripe fish were carefully examined between May 15 and June 20, and while eggs varying in size from barely visible specks to those nearly ripe were found in abundance, no ripe eggs or fully ripe milt were secured.

Up to the close of the year the experiments had led to no tangible results, but much valuable information had been gained regarding the life history of the sturgeon of the Lake of the Woods. The steady and constant decline of the sturgeon fisheries of the coastal and inland waters of the United States indicates the eventual extinction of the species unless the supply is replenished, hence persistent and systematic experiments with the view of artificially propagating the fish will be continued at this station until it is definitely ascertained whether or not the undertaking is feasible.

In this work the Bureau has had the cooperation of the Minnesota and Ontario commissioners of fisheries, and has been authorized to extend its investigations to such points in Canadian waters as may be found desirable.

Use of salt solution.—A weak solution of sodium chlorid (1:9) in water as a means of separating dead eggs from living ones during incubation is now being successfully employed at some of the salmon and lake-trout stations, and its general use in connection with the propagation of the trouts and salmons is contemplated. The foreman of the Yes Bay station reports that with the assistance of one man 10,000,000 salmon eggs were put through the solution in a day's time, and estimates that with the necessary equipment two men could easily remove from 100 to 150 quarts of dead eggs daily. The superintendent of the Northville station states that use of salt solution in the

lake-trout work will reduce the cost of temporary labor for egg picking at least 50 per cent. It will therefore be seen that at the salmon and trout stations where millions of eggs are handled the general adoption of this method means a large annual saving in temporary labor.

Spawning habits of the spotted catfish.—During the summer of 1910 an excellent opportunity was presented of observing the reproductive habits of the spotted catfish, a subject about which little definite information has been obtainable. Only July 9, between the hours of 9 and 10 a. m., a pair of these fish confined among others in a large aquarium in Central Station (Washington, D. C.) were seen to be in spawning condition. They had prepared a nest 8 to 10 inches in diameter by removing the gravel from the bottom of the aquarium, leaving the bare slate exposed. On this space the female deposited a mass of eggs, estimated at 3,000, but all except 50 of the eggs were devoured before the other fish could be removed from the tank. The remaining eggs were taken in charge and tenderly cared for by the male parent, the female apparently taking no further interest in the proceedings. On the fifth day 41 fry were hatched, the water temperature for the period averaging 81° F. The young when hatched were three-eighths of an inch long and of a whitish-pink color, which gradually became darker, assuming a light slate by the eighth day. At 4 days old they became very strong and active, and on the seventh day were fed canned herring roe, to the exclusive use of which is attributed the loss of 29 within 3 days. Beef liver was then substituted. The remaining 12 throve on this diet, reaching a length of 3¼ inches by the middle of November, when the water temperature dropped to 40° F. They then refused food and hibernated in a little cluster in one corner of the aquarium. Early in February the fish were attacked by fungus, which caused the death of 8. The other 4 were in the aquarium at the close of the year and apparently healthy, being 4 inches in length.

Obstructive attitude of States.—The absence of adequate protective fishery laws in some States, lax enforcement of laws in others, and a definite policy of some of the States to limit the Bureau's field of operations greatly retard and curtail its activities. Some of the untoward influences have already been noted, and others may be referred to.

In Nevada the State board of fish commissioners reluctantly grants the Bureau permission to conduct fish-cultural operations in the Truckee River and then only on condition that an unreasonably large percentage of the eggs collected be turned over to the State hatchery. This unfriendly attitude and lack of cooperation is maintained notwithstanding the fact that the Bureau was invited by public men

and interested citizens of the State to take up this particular work and is now being urged to assist in the preservation of the fishes of that river, which are in danger of complete extermination through the absence of protective laws.

On the upper Mississippi River rescue operations are being conducted by authority of permits issued by the several States bordering thereon. The State of Michigan, which has not for years engaged in the cultivation of commercial fishes, has enacted laws directly antagonistic to the Bureau's work, although no other State has profited more from the fish-cultural activities of the Government. The present fish law, passed over the Bureau's protest and serving no useful purpose so far as fish are concerned, not only stipulates that the Government's operations shall be supervised by the State fish and game warden's department, but that all eggs must be taken and fertilized by fishermen licensed by that department, thus placing the work in the hands of inexperienced men. It also prohibits the shipment beyond the boundaries of that State of fish or eggs secured from Michigan waters, but does not prohibit Michigan's reception of eggs or fish from other States. Under these circumstances there has been a steady decline in the output of the Bureau's Michigan stations.

It is hardly necessary to refer again to the steady decline during recent years in the shad fisheries of the Potomac and Susquehanna Rivers, due primarily to the failure of Virginia and Maryland to enact laws to insure the ascent of fish to their spawning grounds. At the present time the Bureau is laboring under great difficulties in its efforts to increase the supply of shad in the Chesapeake region, and until it can secure the cooperation of the responsible States through the enactment and enforcement of adequate fishery laws, the wisdom of further expenditure of time and money in this direction is seriously doubted.

Recently the chairman of a State board of fish and game commissioners requested the Bureau to discontinue operations in one of the lakes of the State on complaint of a summer-hotel keeper who, without any knowledge of the methods employed in artificial propagation or the benefits resulting therefrom and actuated by selfish motives, reached the conclusion that the work of the Bureau was detrimental to the fishing interests in the immediate vicinity of the lake referred to.

BIOLOGICAL INQUIRIES AND EXPERIMENTS.

OYSTER INVESTIGATIONS AND SURVEYS.

Delaware.—At the beginning of the fiscal year there was in progress a survey of the natural oyster beds of Delaware, undertaken at the request of the governor of Delaware acting in his capacity as chair-

man of the Delaware Oyster Survey Commission. The State defrayed part of the expenses for the employment of the temporary assistants required, but most of the work was performed by the regular personnel of the Bureau and the officers and crew of the steamer *Fish Hawk.*

The field work was finished on July 10 and the report, with two charts, was issued February 10, 1911. The investigation was to supplement a survey of the planted oyster beds being made by the State, and the two together make a complete exhibit of the entire oyster-producing bottoms of Delaware.

In the course of the work on the natural beds 16,435 acres, or over 25 square miles, were explored with sounding lines and chains, and 2,144 acres were found to be occupied by oyster beds of varying degrees of productiveness.

The oyster beds, in addition to their mere location, were examined in much detail to determine their condition, history, and prospects. It was found that practically all of the beds on which an active fishery had been prosecuted were showing more or less serious indications of depletion, and some of them were practically obliterated. In some cases this was due to natural causes, but in most instances the methods of the fishery itself were responsible for the condition. The prime factor involved was found to be the lax enforcement of the cull law and the inefficient policing of the beds. The report called attention to the defects in administration and indicated the remedies, and it is hoped that the State will take cognizance of the dangers threatening an important industry and initiate the reforms necessary to guard against them.

Alabama and Mississippi.—As soon as possible after the completion of this work the *Fish Hawk* was dispatched to the Gulf of Mexico for the conduct of similar investigations requested by the States of Alabama and Mississippi. The vessel arrived at Mobile about the beginning of November and was constantly engaged in the survey until May. The work was carried on in cooperation with the Coast and Geodetic Survey, and its progress, despite adverse weather conditions, and much of its enduring value are largely attributed to the services rendered by that bureau in establishing the triangulation on which the hydrographic and biological investigations of this Bureau were based.

The field of operations embraced part of the west side of Mobile Bay and practically all of Mississippi Sound east of Biloxi, an area of approximately 350 square miles. It was the most extensive work of the kind ever undertaken by the Bureau, and embraced in addition to the customary investigations of the natural oyster beds an examination of the barren bottoms in respect to their availability for oyster culture. These examinations involved a study of the oyster food

present, the fluctuations in the salinity of the water, and the consistency of the bottom. In the determination of the latter there was used extensively for the first time an instrument devised by the Bureau which eliminates the personal opinion of the observer and substitutes a mechanical standard. At the end of the fiscal year the field work had been finished and considerable progress had been made in the compilation and plotting of the data.

Oyster enemies.—During the latter part of the year investigations were carried on in respect to the habits and life histories of several destructive enemies of the oyster, in order to determine the most efficient measure to guard planted oyster beds from their inroads. The oyster drill, which annually causes the loss of many thousands of dollars and which can not be efficiently combated by present methods, is being given particular attention.

PEARL-MUSSEL INVESTIGATION.

The Bureau has continued its systematic investigation of the streams of the Mississippi Valley to determine the location, condition, history, and prospects of beds of pearl mussels suitable for utilization in the manufacture of buttons. Partly through the agency of its permanent personnel and largely with the assistance of persons connected with educational institutions in the region, investigations have been carried on in Minnesota, Iowa, Illinois, Arkansas, Missouri, Kentucky, and Tennessee.

While there has not yet developed any grave stringency in the supply of mussels, some of the streams have been depleted to an extent to create concern among both manufacturers and fishermen. Both classes have expressed themselves as favoring some method of regulation of the fishing which will prevent undue waste and destruction of the mussels upon which is dependent the livelihood of many thousands of persons. The Bureau is acquiring much information which will be valuable in the consideration of such measures.

The biological station at Fairport (Iowa), with its trained personnel, is the most important agency in carrying on this inquiry. In addition to the field work it has been actively engaged during the year in propagating and distributing mussels in the waters in its vicinity. A number of investigators have been engaged in experiment and research which will improve the efficiency of this station, and the construction work during the year has had the same purpose in view. When completed this station will be well equipped for extensive practical work in mussel and fish culture, and will be invaluable for the investigation of many economic problems important to the fishing interests of inland waters.

STUDY OF FISH DISEASES.

Investigations of a tumorous disease in cultivated fishes which extensively affects Salmonidæ, especially trout raised under domestication, have been conducted almost continuously throughout the year. A point has been reached which indicates that the source of the infection or other cause of the disease has been localized, and this means the first step in the formulation of measures required for its eradication in the hatcheries. It is still too early to express a definite opinion, but if the present indications should be supported by future research, it appears probable that the work will result in a very considerable saving to the Bureau by making possible a reduction in the mortality among artificially hatched Salmonidæ. In respect to the possible relationship of the disease to analogous affections of human beings nothing conclusive can be stated.

The work has been carried on partly in the experimental aquarium established at the Gratwick Laboratory in Buffalo, and partly in the Craig Brook (Me.) station of the Bureau. The lack of a properly equipped laboratory and experiment station has been seriously felt and is further alluded to in the accompanying recommendations.

During the year the Bureau has made investigation of several fish epidemics and numerous experiments on the effects of various industrial wastes and pollutions on fish life. This subject is important from the viewpoint of many industries other than the fisheries.

PACIFIC COAST SALMONIDÆ.

Investigations concerning the life history and physiology of the Pacific coast salmons were continued during the year, the most interesting inquiries being those conducted with reference to the growth and migration of certain species. A large amount of material and data that were gathered is being utilized in the study of the development and age as recorded in scale structure, and the results thus far obtained demonstrate conclusively that it is possible to determine very accurately the age of our west-coast salmon.

Certain tagging experiments with the steelhead also yielded very interesting results. A large number of these fish were tagged in a small stream flowing into Monterey Bay and many of them returned the next year to the same place in the stream from which they were originally captured.

Among other important results of this work is the discovery of a run of chinook salmon in San Lorenzo River, Santa Cruz County, Cal. No run of Chinook salmon had ever before been reported from this stream, and it is evident this run is the result of plants of chinook salmon fry made there in 1906 and 1907. These results coincide

with similar experiments conducted by the Bureau of Fisheries in Tomales Bay in 1897 and 1898, which resulted in a heavy run of salmon where none had previously occurred.

During August important investigations were conducted on Puget Sound and Frazer River, and data of much value to the International Fisheries Commission were secured. Among other things disclosed by these investigations is the fact that there are in that region two distinct, recognizable forms of chinook salmon, frequenting different portions of those waters and possessing different commercial values.

OTHER INVESTIGATIONS.

Cooperation with the Wisconsin Geological and Natural History Survey in the examination of the lakes in that State has continued and has been extended to include, for purposes of comparison and verification, certain lakes in Minnesota and New York. This system of cooperation secures for the Bureau information of value to fish culture which otherwise could be obtained only with greatly increased difficulty and expense.

At the end of the year a somewhat similar plan was adopted in an examination of the Illinois River with respect to its pollution and biological changes which have been induced in it consequent to the diversion of the flow of the Chicago River. Certain phases of the pearl-mussel investigations appear to be connected with this work.

The work carried on at Sebago Lake for several years was brought to a close during the summer of 1911, most of the data desired having been obtained. In connection with this there has been a continuance of the investigation of Sunapee Lake, N. H., to determine the economic interrelationships of the several food fishes inhabiting that water and to ascertain the effects of fish culture and its proper development in the future.

In response to a strong local demand the Bureau undertook, at the end of the fiscal year, a physical and biological investigation of lakes in Idaho to determine their fitness for the introduction of food fishes and the best means by which their resources can be developed.

In the fall of 1910 arrangements were completed for a comprehensive biological survey of the Canal Zone by various Government scientific bureaus in cooperation with the Smithsonian Institution. The field work concerning the aquatic life was assigned to the Bureau of Fisheries, which detailed for that duty an assistant who went to Panama in December and remained until May. The entire winter was devoted to a careful examination of the fresh waters of the Zone, and extensive collections of the fishes, reptiles, batrachians, and other aquatic species were made. Some collecting was done also

in salt water, and it is the intention to devote another winter to that phase of the field work.

Progress has been made in the study of the great collections obtained by the *Albatross* during the Philippine cruise of 1907–1910. Eminent specialists have undertaken to report on the various groups of aquatic animals, and a number of preliminary papers have already been issued.

MARINE BIOLOGICAL LABORATORIES.

The laboratories of the Bureau at Woods Hole, Mass., and Beaufort, N. C., were open during the usual season in the summer and fall of 1910. They were reopened somewhat earlier than usual in June, 1911, in order to accommodate investigators and to afford facilities for the study of subjects which could be considered to best advantage at that time.

The investigators at the laboratories are of two categories: Those temporarily or permanently in the employ of the Bureau, and independent workers who are merely furnished facilities for carrying on their researches. The former conduct many investigations with more or less bearing on the economic side of the Bureau's work, while the latter often, though not always, select for study subjects of more remote application. Some of the temporary employees carry their investigations to a point where they are economically available, but most of them merely reach a stage in which the basis is laid for future practical adaptation. The contributions to knowledge annually made by the laboratories are considerable. The Bureau, as a rule, publishes those immediately applicable to its work, and the results of all researches are available for its use if required. During the past season the laboratories were generally tested to their full capacity, and some valuable results were attained.

ALASKA FISHERIES SERVICE.

The sundry civil bill approved March 4, 1911, provided for the establishment of the Alaska Fisheries Service, to include the fur-seal service, the salmon fisheries and other fisheries of Alaska, and the fur-bearing animals of Alaska, all of which had been previously administered by the Division of Inquiry Respecting Food Fishes. As this new division was not formally organized until July 1, 1911, detailed explanation of its functions and organization will be reserved for the 1912 annual report.

SALMON AND OTHER FISHERIES.

The usual corps of agents were engaged in the inspection of the salmon fisheries of Alaska, and their vigilance has enforced very general observance of the law. The sentiment against waste or need-

less destruction of edible fish, which the Bureau has from the beginning endeavored to establish, is apparently growing. It is believed, also, that the time will soon come when the use as fertilizer of fish which would otherwise be used as food or bait will be discontinued.

A report giving statistical and other information regarding the commercial fisheries of Alaska, based on the 1910 inspections, has been published and widely distributed. The statistical canvass of the fisheries as therein set forth shows the number of persons engaged to have been 15,620, an increase of 3,032 over the previous year. Of these, 6,836 were whites, 4,147 Indians, 2,411 Chinese, 2,206 Japanese, 4 Koreans, 16 Filipinos, as compared with 5,608 whites, 2,823 Indians, 1,998 Chinese, and 2,159 Japanese in 1909, an increase in 1910 of 1,228 whites, 1,324 Indians, 413 Chinese, and 47 Japanese. It is especially gratifying to note that the increase is chiefly in the whites and Indians employed, as all the Indians and many of the whites are permanent residents of Alaska.

The total investment in the fisheries, exclusive of cash capital ($8,604,437), was $12,106,985, an increase of $2,225,303 as compared with 1909. Nearly all forms of apparatus show increases over 1909. The total quantity of products taken was 214,536,433 pounds, valued at $13,259,859, an increase of 12,553,195 pounds and $2,078,471 over 1909.

The run of salmon was good in all sections except in western Alaska. The number and weight of each species of salmon taken were as follows:

Species.	Number.	Pounds.
Coho or silver	996,684	5,980,104
Dog or chum	2,344,285	18,754,280
Humpback or pink	10,722,966	42,891,864
King or spring	412,543	9,075,946
Sockeye or red	19,202,776	96,013,880
Total	33,679,254	172,716,074

Compared with 1909, there was a decrease of 1,013,354 fish, or 2,312,520 pounds.

The number of canneries operated was 52, of which 23 were in southeast Alaska, an increase of 4 over 1909; 10 in central Alaska, an increase of 2; and 19 in western Alaska, an increase of 1. There were 176 steamers and launches over 5 tons, 55 under 5 tons, and 59 sailing vessels engaged in transporting supplies and the pack. This is a large increase over 1909. The total pack of salmon was 2,438,777 cases, valued at $11,086,322.

The mild-curing of salmon showed a marked increase over the previous year, as did also the shipment of fresh salmon to Puget Sound ports.

All the minor fisheries of Alaska are undergoing development, and each year shows a general increase. Of these, the most important is the halibut, in which nearly a thousand persons are now engaged, and the catch in 1910 amounted to 21,579,289 pounds, valued at $808,010, against only 5,189,924 pounds, valued at $195,529, in 1909. This increase is partly due, however, to transfer of headquarters of American vessels hitherto discharging at Vancouver. The herring fishery yielded $115,765 and the cod fishery $63,443.

FUR SEALS.

An important change in the management of the Alaska fur-seal industry occurred in 1910, in that upon expiration of the lease of the North American Commercial Co. on May 1, 1910, direct charge of all operations was taken over by the Government and the leasing system was abandoned, under the act approved April 21, 1910.

At a conference of the chief agent with officials of the North American Commercial Co. on May 23, arrangements were made for the purchase of the company's property on St. Paul and St. George Islands, and the formal transfer was accomplished July 1.

It was agreed that all company houses, native dwellings, wharves, ways, derricks, tools, and implements should be taken at the invoice price less 50 per cent; all household goods and office furniture at invoice price less 25 per cent; all live stock, sea-lion skins, drugs, and instruments (less 50 per cent on St. George), groceries in company house, salt, and seal twine at invoice price; all fox traps at invoice valuation; all coal at $17 per ton; all boats, launches, bidarrahs, telephone line (less 50 per cent on St. George), and library at lump sums; and all other articles at San Francisco invoice cost April 30, 1910, corrected to date of transfer. In accordance with the above understanding, payment was duly made to the North American Commercial Co. in the sum of $60,568.17, itemized as follows:

St. George Island.

Buildings	$9,125.50	
Furniture	1,530.13	
Tools and implements	582.23	
Telephone line and equipment	148.62	
Library	100.00	
Live stock	313.72	
Wharf and equipment	868.61	
Boats	700.00	
Merchandise in store	6,874.53	
Medical supplies and surgical instruments	359.48	
Coal	646.00	
Sea-lion skins	85.71	
Total for St. George Island		$21,334.53

St. Paul Island.

Buildings	$21,476.27	
Furniture	2,337.90	
Tools and implements	1,812.66	
Telephone line and equipment	90.00	
Library and school supplies	457.00	
Live stock	967.62	
Wharves and equipment	402.31	
Boats, including launch	3,200.00	
Merchandise in store	6,401.27	
Medical supplies and surgical instruments	818.45	
Coal	1,132.16	
Sea-lion skins	138.00	
Total for St. Paul Island		$39,233.64
Total paid North American Commercial Co		60,568.17

The killing of seals under the new system was conducted under immediate direction of the Government agents. The law prohibits the killing of female seals and any seal under 1 year of age, and the Department regulations as usual fixed the weight limits for skins at 5 and $8\frac{1}{2}$ pounds, thus restricting the killable seals to males 2 and 3 years old. The total number of skins taken subsequent to the shipment by the North American Commercial Co. in the fall of 1909 was as follows:

On St. Paul Island:		
Taken in food drives between Aug. 9, 1909, and June 17, 1910	1,572	
Found dead at Rocky Point	1	
Taken in regular drives between July 3 and 31, 1910	8,683	
Taken in food drive Aug. 10, 1910	496	
		10,752
On St. George Island:		
Taken for food in August to November, 1909	500	
Taken in regular drives June and July, 1910	2,314	
Taken for food in spring of 1910	16	
Left in salt house from 1909	4	
		2,834
Total		13,586
Turned over to North American Commercial Co. to complete quota of 15,000 for 1909		664
Shipped from islands by Government Aug. 28, 1910		12,920
Left in salt house on St. George Island		2
Total		13,586

Realizing that London is the only place in the world where fur-seal skins can at the present time be properly handled in every way, it was decided, after mature deliberation, to sell the skins there, in accordance with the uniform practice of the last 40 years and more. The 12,920 skins shipped by the Government were therefore con-

signed to Messrs. C. M. Lampson & Co., London, who received them early in October. On December 16, 1910, they were placed on sale at the auction rooms of the firm and brought the gross sum of £89,624 16s., less discount (2½ per cent) for cash, or £87,384. 3s. 7d. The United States being credited with the casks (228 in number) to the value of £35 3s., and with salt shaken from the skins to the value of £2 19s. 3d., the total receipts were £87,422 5s. 10d., or about $424,000. Deducting from this sum the freight, insurance, and brokerage charges, the net proceeds of the sale were $403,946.94, checks in which amount were duly received.

MINOR FUR-BEARING ANIMALS OF ALASKA.

The act approved April 21, 1910, gave the Department of Commerce and Labor jurisdiction over the minor fur-bearing animals of Alaska which, up to that time, had been under the Treasury Department.

Immediately upon the passage of this law the Bureau began consideration of the various questions which should receive attention in the development of a rational policy for handling this important matter. A careful study was made of the laws and regulations in the Canadian Provinces and in the various States intended for the protection of fur-bearing animals, and a series of regulations (Department Circular No. 206) was issued June 2, 1910, in which open seasons were provided for land otter, mink, muskrat, marten, fisher, ermine, black bear, fox, wildcat, and lynx. This circular was reissued March 8, 1911 (as Alaska Fisheries Service Circular No. 1), with certain modifications.

The sundry civil bill making appropriations for the fiscal year ending June 30, 1912, provided for the appointment of one warden and four deputy wardens whose duties are to see that the law and the regulations are observed and to make such study of the habits, abundance, and distribution of the various species of fur-bearing animals as will be helpful in forming regulations which will permit the largest annual take of pelts consistent with adequate protection and conservation of the species.

Until now there has been no way by which complete statistics of the annual shipment of furs from Alaska could be obtained. Accurate records are kept, of course, of the number and value of the fur-seal skins, also of all other furs shipped out of Alaska by freight or express and passing through the customhouses, but records of shipments by mail have been lacking. Through the courtesy of the Post Office Department an arrangement has been made whereby this deficiency will now be remedied. Blank forms (Alaska Fisheries Service Form No. 1) are supplied to the various postmasters and

shippers to be filled out and signed by the shipper, certified by the postmaster, and forwarded to the Bureau. The number of such completed blanks already received shows that the quantity of furs sent out by mail is very great. Similar blanks (Alaska Fisheries Service Forms No. 2 and 2[a]) have been provided for all shipments other than by mail.

The importance of Alaska as a producer of furs has usually been thought of only in connection with the fur seal. As a matter of fact the pelts from the minor fur-bearing animals possess at present a greater annual value in the aggregate than those from the fur seal.

The available statistics for 1910 show that the furs shipped from Alaska during that year, exclusive of the fur seal, amounted to $445,376. As this does not include the furs shipped by mail, or those taken out as baggage, it is believed that the total output greatly exceeded a half million dollars; and it is confidently believed that with proper conservation and regulation the total annual take can be increased to more than a million dollars without in any way endangering the supply of the species.

COMMERCIAL FISHERIES.

The work of collecting statistics of the oyster fisheries of the Atlantic coast and of the shad fisheries of the South Atlantic States and some other sections, which was begun in the spring of 1910, was continued during the year and is still in progress. Statistics have been secured for the oyster fisheries of the New England, South Atlantic, and Gulf States, and the shad fisheries of the South Atlantic States and the Hudson and Delaware Rivers.

OYSTER INDUSTRY OF NEW ENGLAND STATES.

Although the natural oyster beds within the New England States have always been far inferior to those possessed by most of the maritime States farther south, Connecticut, Rhode Island, and Massachusetts for many years have been an important factor in the oyster industry. The early settlement of a large population in the coastal region and the proximity of New York City, together with the comparatively small area of natural beds and the precariousness of the natural set of spat, operated at an early period to render the supply inadequate to the demand. But this condition made imperative the adoption of a system of oyster culture under private ownership which has resulted in overcoming the handicap imposed by the poverty of the natural production.

Originally the jurisdiction over this development and the power to lease or otherwise grant the barren bottoms for purposes of oyster culture was vested in the tide-water municipalities or other minor political bodies, but eventually this local administration demonstrated its incapacity to adapt itself to the legitimate development.

Connecticut and Rhode Island recognized this by legislation vesting a State commission with jurisdiction over most of the available area within their respective limits, but Massachusetts has adhered to the antiquated policy of local control.

According to a canvass made by the Bureau during the fiscal year covered by this report, the yield of oysters in New England in 1910 was 5,827,821 bushels, valued at $3,589,719, of which 5,547,418 bushels, valued at $3,439,400, came from private beds and but 280,403 bushels, mostly seed oysters, valued at $150,319, were from public areas. In addition to the product of oysters, the fisheries yielded 114,200 bushels of shells, with a value of $7,315. There was invested in the business $2,164,007 exclusive of cash capital.

There were under lease or otherwise held by private persons for purposes of oyster culture in New England in 1910, 124,737.69 acres, valued with improvements and oyster contents at $3,611,168. Of this area but 45,514.37 acres were under actual cultivation. The proportion of bottoms cultivated to the area held is less than 9 per cent in Massachusetts, 93 per cent in Rhode Island, and 33 per cent in Connecticut. The reason for the low percentage in Massachusetts is that the conditions of tenure are lenient and even lax, and a considerable proportion of the area held is of but little value. In Connecticut the State sold the bottoms outright for a nominal sum and until the time at which the canvass was made imposed a very low tax rate. In consequence, large areas were purchased and are now held as speculation, or to prevent competitors from acquiring them, or, more legitimately, as a means to protect the areas actually planted from a dearth in the supply of oyster food. In Rhode Island, on the contrary, the bottoms are leased at a high rental and must yield an income to financially justify the expense.

The other features of the canvass are intelligible from the following tables:

STATISTICS OF THE OYSTER INDUSTRY OF THE NEW ENGLAND STATES, 1910.

MASSACHUSETTS.

Items.	Private areas.		Public areas.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Persons employed:						
On vessels fishing	25				25	
In shore or boat fisheries	345		8		353	
Shoresmen	104				104	
Total	474		8		482	
Wages paid:						
Dredging		$11,659				$11,659
Tonging		7,902		$2,011		9,913
Planting and transplanting		19,229				19,229
Protecting grounds from natural enemies		95				95
Wholesale trade		61,440				61,440
Total		100,325		2,011		102.336

STATISTICS OF THE OYSTER INDUSTRY OF THE NEW ENGLAND STATES, 1910—Continued.

MASSACHUSETTS—Continued.

Items.	Private areas.		Public areas.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Vessels, boats, apparatus, and other property:						
Vessels fishing	15	$31,200			15	$31,200
Net tonnage	132				132	
Gasoline boats	41	21,525			41	21,525
Sail and row boats	299	12,880	8	$125	307	13,005
Apparatus—vessel fisheries—Dredges	38	581			38	581
Apparatus—shore fisheries—Dredges	154	958			154	958
Tongs	249	898	10	43	259	941
Shore and accessory property		165,208		5		165,213
Total		233,250		173		233,423
Planting operations:						
Oyster grounds owned or leased—Town grounds ... acres	24,241.77	205,820			24,241.77	205,820
Oyster grounds under culture—Town grounds ... acres	2,315.92				2,315.92	
Grounds planted during the year ... acres	911.87				911.87	
Material planted during the year—Seed oysters ... bushels	192,331	106,460			192,331	106,460
Oyster shells ... do	95,379	3,406			95,379	3,406
Total		109,866				109,866
Oysters on private beds at the end of the year ... bushels	481,921	357,773			481,921	357,773
Expenses of planting and transplanting		11,480				11,480
Expenses of protecting grounds from natural enemies		41,064				41,064
Total		52,544				52,544
Products:						
Vessel fisheries—With dredges—Market oysters ... bushels	152,458	158,131			152,458	158,131
Seed oysters ... do	5,500	2,325			5,500	2,325
Total	157,958	160,456			157,958	160,456
Shore fisheries—With dredges—Market oysters ... bushels	34,448	62,020			34,448	62,020
Seed oysters ... do	26,735	13,614			26,735	13,614
Oyster shells ... do	1,900	50			1,900	50
With tongs, etc.—Market oysters ... do	51,182	92,818	25	50	51,207	92,868
Seed oysters ... do	11,635	4,560	5,560	2,006	17,195	6,566
Total	125,900	173,062	5,585	2,056	131,485	175,118
Grand total	283,858	333,518	5,585	2,056	289,443	335,574
Wholesale trade:						
Market oysters sold in the shell ... bushels	56,475	87,863			56,475	87,863
Oysters sold opened ... gallons	542,136	644,438			542,136	644,438
Total		732,301				732,301
Expenses of wholesale trade		41,064				41,064

STATISTICS OF THE OYSTER INDUSTRY OF THE NEW ENGLAND STATES, 1910—Continued.

RHODE ISLAND.

Items.	Private areas.		Public areas.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Persons employed:						
On vessels fishing	225				225	
On vessels transporting	9		3		12	
In shore or boat fisheries	158		283		441	
Shoresmen	1,069				1,069	
Total	1,461		286		1,747	
Wages paid:						
Dredging		$88,668		$6,250		$94,918
Tonging		1,520		32,000		33,520
Transporting		3,458		180		3,638
Planting and transplanting		95,842				95,842
Protecting grounds from natural enemies		19,218				19,218
Wholesale trade		317,082				317,082
Total		525,788		38,430		564,218
Vessels, boats, apparatus, and other property:						
Vessels fishing	56	241,800			56	241,800
Net tonnage	1,203				1,203	
Vessels transporting	4	8,300	2	5,000	6	13,300
Net tonnage	79		16		95	
Gasoline boats	44	30,925	134	37,150	178	68,075
Sail and rowboats	193	17,445	297	13,855	490	31,300
Apparatus—vessel fisheries—						
Dredges	160	5,200			160	5,200
Maps	71	1,680			71	1,680
Apparatus—shore fisheries—						
Dredges	48	965	150	450	198	1,415
Tongs	53	262	309	1,545	362	1,807
Maps	6	150			6	150
Shore and accessory property		454,027				454,027
Total		760,754		58,000		818,754
Planting operations:						
Oyster grounds owned or leased—						
State grounds ... acres	16,603.70	1,456,028			16,603.70	1,456,028
Town grounds ... do	558.37	52,727			558.37	52,727
Total	17,162.07	1,508,755			17,162.07	1,508,755
Oyster grounds under culture—						
State grounds ... acres	15,383.30				15,383.30	
Town grounds ... do	543.90				543.90	
Total	15,927.20				15,927.20	
Grounds planted during the year ... acres	6,038.00				6,038.00	
Material planted during the year—						
Seed oysters ... bushels	1,484,155	785,229			1,484,155	785,229
Oyster shells ... do	1,669,799	102,115			1,669,799	102,115
Gravel, etc ... cubic yards	38	50			38	50
Total		887,394				887,394
Oysters on private beds at the end of the year ... bushels	4,015,142	2,143,197			4,015,142	2,143,197
Expenses of planting and transplanting		21,751				21,751
Expenses of protecting grounds from natural enemies		1,482				1,482
Total		23,233				23,233

STATISTICS OF THE OYSTER INDUSTRY OF THE NEW ENGLAND STATES, 1910—Continued.

RHODE ISLAND—Continued.

Items.	Private areas.		Public areas.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Products:						
Vessel fisheries—						
With dredges—						
Market oysters.......bushels..	1,974,763	$1,206,044			1,974,763	$1,206,044
Seed oysters...........do....	41,475	18,875			41,475	18,875
Total	2,016,238	1,224,919			2,016,238	1,224,919
Shore fisheries—						
With dredges—						
Market oysters.......bushels..	141,090	87,315			141,090	87,315
Seed oysters...........do....	10,600	2,980	12,500	$6,250	23,100	9,230
With tongs—						
Market oysters.........do....	13,885	11,682	1,500	1,350	15,385	13,032
Seed oysters...........do....	4,950	1,980	67,515	32,225	72,465	34,205
Total	170,525	103,957	81,515	39,825	252,040	143,782
Grand total	2,186,763	1,328,876	81,515	39,825	2,268,278	1,368,701
Wholesale trade:						
Market oysters and sold in the shell.................bushels..	442,937	335,977			442,937	335,977
Oysters sold opened......gallons..	1,215,833	1,292,991			1,215,833	1,292,991
Seed oysters sold or transferred to other States.........bushels..	8,570	6,000			8,570	6,000
Oyster shells sold...........do....	257,322	14,966			257,322	14,966
Total		1,649,934				1,649,934
Expenses of wholesale trade		133,233				133,233

CONNECTICUT.

Items.	Private areas.		Public areas.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Persons employed:						
On vessels fishing	498		159		657	
On vessels transporting	20		2		22	
In shore or boat fisheries	204		331		535	
Shoresmen	1,489				1,489	
Total	2,211		492		2,703	
Wages paid:						
Dredging		$207,558		$52,647		$260,205
Tonging		7,872		11,565		19,437
Transporting		12,334		480		12,814
Planting and transplanting		114,775				114,775
Protecting grounds from natural enemies		31,264				31,264
Wholesale trade		273,142				273,142
Total		646,945		64,692		711,637
Vessels, boats, apparatus, and other property:						
Vessels fishing	86	559,190	75	36,925	161	596,115
Net tonnage	3,290		573		3,863	
Vessels transporting	7	53,300	1	400	8	53,700
Net tonnage	397		15		412	
Gasoline boats	18	7,535	11	3,700	29	11,235
Sail and row boats	185	15,115	340	17,282	525	32,397
Apparatus—vessel fisheries—						
Dredges	277	8,331	361	1,802	638	10,133
Maps	77	1,475			77	1,475
Apparatus—shore fisheries—						
Dredges	18	97	173	869	191	966
Tongs	124	480	344	2,159	468	2,639
Maps	2	10			2	10
Shore and accessory property		403,160				403,160
Total		1,048,693		63,137		1,111,830

STATISTICS OF THE OYSTER INDUSTRY OF THE NEW ENGLAND STATES, 1910—Continued.

CONNECTICUT—Continued.

Items.	Private areas.		Public areas.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Planting operations:						
Oyster grounds owned or leased—						
State grounds....acres..	74,152	$1,759,968	....	....	74,152	$1,759,968
Town grounds....do....	9,182	136,625	....	....	9,182	136,625
Total....	83,334	1,896,593	....	....	83,334	1,896,593
Oyster grounds under culture—						
State grounds....acres..	25,293	....	....	....	25,293	....
Town grounds....do....	1,979	....	....	....	1,979	....
Total....	27,272	....	....	....	27,272	....
Grounds planted during the year....acres..	5,955.05	....	....	....	5,955.05	....
Material planted during the year—						
Seed oysters....bushels..	219,923	107,899	....	....	219,923	107,899
Oyster shells....do....	3,186,001	234,895	....	....	3,186,001	234,895
Gravel, etc....cubic yards..	215,490	2,656	....	....	215,490	2,656
Total....	....	345,450	....	....	....	345,450
Oysters on private beds at the end of the year....bushels..	3,784,175	1,856,285	....	....	3,784,175	1,856,285
Expenses of planting and transplanting....	....	51,883	....	....	....	51,883
Expenses of protecting grounds from natural enemies....	....	2,220	....	....	....	2,220
Total....	....	54,103	....	....	....	54,103
Products:						
Vessel fisheries—						
With dredges—						
Market oysters....bushels..	1,034,334	657,184	400	$275	1,034,734	657,459
Seed oysters....do....	1,683,842	939,076	114,074	56,650	1,797,916	995,726
Total....	2,718,176	1,596,260	114,474	56,925	2,832,650	1,653,185
Shore fisheries—						
With dredges—						
Market oysters....bushels..	151,666	53,846	....	....	151,666	53,846
Seed oysters....do....	56,589	31,160	44,384	23,533	100,973	54,693
With tongs, etc.—						
Market oysters....do....	138,225	90,760	25,390	23,995	163,615	114,755
Seed oysters....do....	14,041	5,030	9,055	3,985	23,096	9,015
Oyster shells....do....	....	....	112,300	7,265	112,300	7,265
Total....	360,521	180,796	191,129	58,778	551,650	239,574
Grand total....	3,078,697	1,777,056	305,603	115,703	3,384,300	1,892,759
Wholesale trade:						
Market oysters sold in the shell....bushels..	512,379	382,437	....	....	512,379	382,437
Oysters sold opened....gallons..	1,082,960	1,168,761	....	....	1,082,960	1,168,761
Seed oysters sold or transferred to other States....bushels..	932,958	511,139	....	....	932,958	511,139
Oyster shells sold....do....	470,050	26,282	....	....	470,050	26,282
Total....	....	2,088,619	....	....	....	2,088,619
Expenses of wholesale trade....	....	210,079	....	....	....	210,079

STATISTICS OF THE OYSTER INDUSTRY OF THE NEW ENGLAND STATES, 1910—Continued.

GRAND TOTAL.

Items.	Number.	Value.
Persons employed:		
On vessels fishing	907	
On vessels transporting	34	
In shore or boat fisheries	1,329	
Shoresmen	2,662	
Total	4,932	
Wages paid:		
Dredging		$366,782
Tonging		62,870
Transporting		16,452
Planting and transplanting		229,846
Protecting grounds from natural enemies		50,577
Wholesale trade		651,664
Total		1,378,191
Vessels, boats, apparatus and other property:		
Vessels fishing	232	869,115
Net tonnage	5,198	
Vessels transporting	14	67,000
Net tonnage	507	
Gasoline boats	248	100,835
Sail and row boats	1,322	76,702
Apparatus—vessel fisheries—		
Dredges	836	15,914
Mops	148	3,155
Apparatus—shore fisheries—		
Dredges	543	3,339
Tongs	1,089	5,387
Mops	8	160
Shore and accessory property		1,022,400
Total		2,164,007
Planting operations:		
Oyster grounds owned or leased—		
State grounds....acres	90,756	3,215,996
Town grounds....do	33,982	395,172
Total	124,738	3,611,168
Oyster grounds under culture—		
State grounds....acres	40,676	
Town grounds....do	4,838	
Total	45,514	
Grounds planted during the year....acres	12,905	
Planting operations—Con.		
Material planted during the year—		
Seed oysters...bushels	1,896,409	$999,588
Oyster shells.....do	4,951,179	340,416
Gravel, etc....cu. yds	215,528	2,706
Total		1,342,710
Oysters on private beds at the end of the year ....bushels	8,281,238	4,357,255
Expenses of planting and transplanting		85,114
Expenses of protecting grounds from natural enemies		3,702
Total		88,816
Products:		
Vessel fisheries—		
With dredges—		
Market oysters, bushels	3,161,955	2,021,634
Seed oysters..bushels	1,844,891	1,016,926
Total	5,006,846	3,038,560
Shore fisheries—		
With dredges—		
Market oysters, bushels	327,204	203,181
Seed oysters.bushels	150,808	77,537
Oyster shells...do	1,900	50
With tongs, etc.—		
Market oysters, bushels	230,207	220,655
Seed oysters.bushels	112,756	49,786
Oyster shells...do	112,300	7,265
Total	935,175	558,474
Grand total	5,942,021	3,597,034
Wholesale trade:		
Market oysters sold in the shell.......bushels	1,011,791	806,277
Oysters sold opened, gallons	2,840,929	3,106,190
Seed oysters sold or transferred to other States ....bushels	941,528	517,139
Oyster shells sold...do	727,372	41,248
Total		4,470,854
Expenses of wholesale trade		384,376

COMPARATIVE STATISTICS OF THE OYSTER PRODUCT OF THE NEW ENGLAND STATES FOR VARIOUS YEARS FROM 1880 TO 1910.[1]

Years.	Massachusetts.		Rhode Island.		Connecticut.		Total.	
	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels	Value.
1880	36,000	$41,800	163,200	$225,500	336,450	$386,625	535,650	$653,925
1887	43,183	64,115	194,030	261,026	1,376,086	998,823	1,613,299	1,323,964
1888	45,631	66,453	189,255	252,601	1,509,867	1,012,259	1,744,753	1,331,313
1889	36,981	65,538	203,459	271,939	1,485,861	1,055,807	1,726,301	1,393,284
1892	64,807	83,638	174,446	259,242	1,940,174	1,426,249	2,179,427	1,769,129
1898	101,225	156,235	457,378	505,378	2,090,469	1,249,071	2,649,072	1,910,684
1902	103,386	133,682	608,029	588,052	2,081,534	1,471,582	2,792,949	2,193,316
1905	142,230	221,990	916,088	929,963	3,687,424	2,809,832	4,745,742	3,961,785
1908	154,900	217,980	1,228,900	969,490	3,948,100	2,582,940	5,331,900	3,770,410
1910	287,543	335,524	2,268,278	1,368,701	3,272,000	1,885,494	5,827,821	3,589,719

[1] The statistics of the oyster product for 1908 are from data published by the Bureau of the Census.

SHAD FISHERIES.

Hudson River.—The canvass of the shad fishery of the Hudson extended from the mouth of the river to Hudson, in Columbia County, N. Y., which is about the highest point to which commercial fishing extends; New York Bay and Raritan Bay and its tributaries were also included, although in recent years the catch of shad in that section has been inconsiderable, owing probably to the great amount of refuse discharged into these waters.

In the river proper the apparatus of capture consists almost entirely of gill nets, of which the majority are drifted. At Malden, in Ulster County, N. Y., where there are more drift nets fished than at any other single place on the river, the catch was the largest in six or eight years. The best drifting grounds, however, are in the vicinity of Rhinebeck and Hyde Park, the average take per net there being larger than elsewhere. Only nine seines were operated for shad along the entire river in 1910, and seine fishing has practically been abandoned during recent years because the small hauls have not justified the expense. Only stake gill nets are used along the New Jersey shore of the Hudson, and the fishery is usually quite remunerative, the catch in 1910 being fully up to the average for a number of seasons.

From the following condensed statistics it appears that the Hudson River shad fishery in 1910 yielded 228,254 shad, for which the fishermen received $100,824. The catch was reported to be somewhat better than in the previous year, but the trend of the fishery is downward. Compared with the year 1896, for example, the yield of shad in 1910 fell off about two-thirds while the value increased one-fourth.

STATISTICS OF THE SHAD FISHERY OF THE HUDSON RIVER IN NEW YORK AND NEW JERSEY IN 1910.[1]

Items.	New York.		New Jersey.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Fishermen	353		172		525	
Sail and row boats	161	$6,938	64	$2,610	225	$9,548
Gasoline boats	1	200	25	17,340	26	17,540
Gill nets	316	11,492	523	2,387	839	13,879
Seines	9	610	12	2,868	21	3,478
Fyke nets	6	300	65	1,050	71	1,350
Pound nets	1	400	38	19,900	39	20,300
Shore and accessory property		325		6,450		6,775
Total		20,265		52,605		72,870
Shad caught:						
With gill nets	118,034	47,860	79,950	40,075	197,984	87,935
With seines	4,000	1,605	4,550	2,275	8,550	3,880
With fyke nets	3,000	1,500	6,800	3,400	9,800	4,900
With pound nets	1,500	750	10,420	3,359	11,920	4,109
Total	126,534	51,715	101,720	49,109	228,254	100,824

[1] These statistics include Lower New York Bay, and Raritan Bay and tributaries.

Delaware River.—The Delaware has long been the principal shad stream, and notwithstanding a marked decline in the fishing in recent years the river still retains its rank. Most of the fishing in Delaware Bay is done by fishermen living on the river, who meet the migrating shad below the mouth of the river and follow them upstream. The statistics therefore cover the entire industry from the mouth of the river to the upper limit of commercial fishing, in Pike County, Pa.

The shad fishery of New Jersey is much more important than that of Delaware and Pennsylvania combined, and the most productive grounds are about the mouth of the river, in the vicinity of Bayside. Drift gill nets, 500 to 800 fathoms long, are the principal apparatus used in the bay and lower part of the river, and nearly every fisherman has a gasoline boat. Below Trenton, 6 seines were used on the New Jersey shore and 4 in Bucks County, Pa.; above Trenton, only seines are employed. At various places on the river, but especially in the neighborhood of Philadelphia and Camden, the fishermen complain of the damage done to the shad run by the pollution of the water by city and factory wastes.

The Delaware River shad fishery in 1910, as shown by the following condensed table, gave employment to over 1,400 fishermen, with apparatus and other property worth nearly a quarter of a million dollars. The catch was 951,250 fish, for which the fishermen received $402,401. While the run was said to be larger than for several years, it was nevertheless much less than formerly; as, for instance, in 1896, when the Bureau made a canvass of the river that showed a catch of 2,778,803 shad, with a value of $300,598. The average price received for shad by the fishermen in 1910 was over 42 cents apiece, while in 1896 it was less than 11 cents apiece.

SHAD FISHERIES OF DELAWARE RIVER IN DELAWARE, PENNSYLVANIA, AND NEW JERSEY IN 1910.

Items.	Delaware.		Pennsylvania.		New Jersey.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.	Number.	Value.
Fishermen	188		242		1,033		1,463	
Boats	99	$27,250	89	$8,677	615	$108,347	803	$144,274
Gill nets	94	12,510	57	2,125	448	39,879	599	54,514
Seines			19	2,480	21	3,340	40	5,820
Shore property		550		2,681		14,160		17,391
Total		40,310		15,963		165,726		221,9[illegible]9
Shad caught:								
With gill nets	145,500	59,821	35,800	16,575	662,200	277,640	843,500	354,036
With seines			59,650	26,730	48,100	21,635	107,750	48,365
Total	145,500	59,821	95,450	43,305	710,300	299,275	951,250	402,401

South Atlantic States.—In the canvass of the shad fishery of the South Atlantic States, the summarized results of which are shown in the following table, the Bureau's agents covered all operations of a commercial character, including the semiprofessional fishing in the upper parts of many of the streams. The statistics therefore give a complete exposition of the extent and condition of this important branch.

In North Carolina the shad has always been more abundant and valuable than in all the other States of this region; and in 1910 the fishery yielded the fishermen a larger sum than in any other year for which statistics are available, although the catch was considerably less than during several seasons 12 to 15 years before. Noteworthy features of the North Carolina shad fishery are the large increase in the use of pound nets and the decline in seines, the former apparatus now taking more than half the product; and the commendable legislation which has given the shad in the northeastern parts of the State a fair opportunity to reach the spawning grounds.

The shad fishery in South Carolina has increased slightly, but the actual money returns to the fishermen are much larger than formerly. In Georgia the figures for 1910 show a marked decline in catch, which is not compensated for by the increased price.

The shad fishery of Florida is practically confined to St. Johns River, in which the run in 1910 was very much smaller than in recent years, although the high prices commanded by the fish caught there early in the season and shipped to the northern markets have enabled the fishermen to conduct a rather successful business.

Statistics of the Shad Fishery of the South Atlantic States, 1910.

Items.	North Carolina.		South Carolina.		Georgia.		Florida.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.	Number.	Value.	Number.	Value.
Fishermen	1,898	......	307	......	473	......	364	......	3,042	......
Boats	1,031	$96,801	159	$4,394	301	$5,003	199	$21,515	1,690	$127,713
Gill nets	22,647	41,979	207	9,665	287	16,745	149	12,235	23,290	80,624
Seines	48	14,015	......	......	......	......	27	2,625	75	16,640
Pound nets	3,073	181,170	......	......	......	......	......	......	3,073	181,170
Bow nets	133	651	......	......	......	......	......	......	133	651
Shore property	......	37,800	......	1,310	......	1,725	......	10,235	......	51,070
Total	......	372,416	......	15,369	......	23,473	......	46,610	......	457,868
Shad caught:										
With gill nets	459,611	156,005	132,499	65,756	82,630	44,911	130,538	66,783	805,278	333,455
With seines	68,017	23,669	......	......	......	......	72,257	33,480	140,274	57,149
With pound nets	763,619	239,659	......	......	......	......	......	......	763,619	239,659
With bow nets	4,970	2,138	......	......	......	......	......	......	4,970	2,138
Total	1,296,217	421,471	132,499	65,756	82,630	44,911	202,795	100,263	1,714,141	632,401

FISH LANDED AT BOSTON AND GLOUCESTER.

Statistics of the vessel fisheries of Boston and Gloucester, Mass., were collected by the local agents there, and the returns have been published as monthly and annual bulletins and distributed to the trade in various parts of the country, giving by months and by fishing grounds the quantity and value of the fishery products landed at those ports by American fishing vessels during the calendar year. The fleet includes not only vessels owned at Boston and Gloucester, but also a considerable number from other ports on the New England coast, especially in Massachusetts and Maine.

In 1910 the number of trips landed at Boston was 4,548, aggregating 102,090,154 pounds of fish, valued at $2,711,521, and at Gloucester 2,011 trips were landed, aggregating 79,644,118 pounds, valued at $2,121,820; a total of 6,559 trips, and of 181,734,272 pounds of fish, having a value to the fishermen of $4,833,341. Compared with the previous year there was an increase of 253 trips, and of 8,632,048 pounds in the quantity and $216,897 in the value of fish landed. There was a decrease in the quantity of cod, halibut, and mackerel landed, but an increase in that of cusk, haddock, hake, pollock, and herring. Owing to the large demand for cod and the decrease in the catch by the American fleet, the dealers at Gloucester imported from Newfoundland and Nova Scotia, chiefly the former, 1,964,068 pounds of salted fish, valued at $76,716, in November and December, 1910, and 2,080,736 pounds, valued at $85,225, in the early part of 1911; a total for the season of 4,044,804 pounds, valued at $161,941. This includes 175,811 pounds of cod, valued at $7,472, and 4,170 pounds of halibut, valued at $334 in 1910, and 153,433 pounds of cod, valued at $6,521 in 1911, landed by American fishing vessels free of duty. The remainder was landed by American and British vessels and was dutiable. These products, which were not included in the bulletins for the year, are given by species in the following table:

Species.	1910		1911		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Cod	1,944,736	$76,116	2,064,446	$84,940	4,009,182	$161,056
Haddock	10,335	181	10,220	179	20,555	360
Hake	720	13	6,070	106	6,790	119
Pollock	4,107	72			4,107	72
Halibut	4,170	334			4,170	334
Total	1,964,068	76,716	2,080,736	85,225	4,044,804	161,941

The decrease in the catch of halibut landed at Boston and Gloucester may be accounted for by the fact that large quantities of this

species were landed at Portland, Me. The mackerel season was the poorest on record for both fresh and salted mackerel, the catch amounting to only 19,950 barrels fresh and 3,395 barrels salted in 1910, against 46,439 barrels fresh and 17,542 barrels salted in 1909. The quantity of mackerel landed at Boston during the year was 486,400 pounds fresh, valued at $48,737, and 31,000 pounds salted, valued at $2,617, and at Gloucester 96,400 pounds fresh, valued at $7,907, and 578,600 pounds salted, valued at $51,217.

The catch of mackerel during the season of 1911, up to the 1st of July, showed an increase over that of the previous year, due to the success of the Cape Shore fleet, nearly all of which returned with good trips and landed more fresh mackerel than for a number of years past. The southern fleet of seiners was small and the catch very light. The netters were, as a whole, unsuccessful. The fleet comprised about the same number of vessels as in the previous year.

The mackerel landed by both seiners and netters were practically all large, only a few medium fish being taken. The fresh mackerel sold at good prices, from 12 to 60 cents each, and the salted mackerel from $13 to $15 a barrel. The first mackerel secured this season were landed on May 1 by the schooner *Victor*, Capt. John McFarland, the fare consisting of 450 large fish caught 70 miles southeast of Cape Henlopen. Capt. McFarland reported mackerel in small schools and wild. The fishermen also saw large schools of mackerel on the southern grounds this spring that could not be caught with the seine. In past years when mackerel were abundant there was a large body of medium mackerel off the coast, but these fish have been scarce in recent years. Following is the catch and value of fresh and salted mackerel taken by the fleet from the beginning of the season to the 1st of July each year from 1907 to 1911:

Years.	Fresh.		Salted.	
	Barrels.	Value.	Barrels.	Value.
1907	31,620	$382,157	9,503	$104,533
1908	33,018	407,674	14,872	141,282
1909	30,354	352,668	11,540	118,285
1910	16,410	239,962	2,490	38,595
1911	26,845	268,450	5,301	46,221

Statistics of the quantity and value of fishery products landed at Boston and Gloucester by American fishing vessels during the year, except those previously noted as not included in the monthly and annual bulletins, are given in detail on the following pages.

QUANTITIES AND VALUES OF CERTAIN FISHERY PRODUCTS LANDED AT BOSTON AND GLOUCESTER, MASS., BY AMERICAN FISHING VESSELS DURING THE YEAR 1910, BY MONTHS.

Months.	No. of trips.	Cod.				Cusk.				Haddock.			
		Fresh.		Salted.		Fresh.		Salted.		Fresh.		Salted.	
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON.													
January	370	1,186,400	$34,026			129,400	$2,639			5,685,600	$143,298		
February	393	1,687,400	69,232			119,800	3,057			5,344,000	175,712		
March	436	2,848,700	61,237			197,800	3,336			5,373,600	107,622		
April	344	1,830,900	45,708			375,300	5,764			3,919,400	61,322		
May	292	2,135,800	71,074			368,100	4,989			1,627,600	52,776		
June	283	2,406,200	76,918			102,000	2,028			2,296,900	71,020		
July	308	3,335,100	74,488			113,200	1,546			2,487,700	56,236		
August	409	3,965,600	100,655			51,000	813			4,542,550	83,737		
September	362	2,303,800	81,720			67,500	1,266			5,226,670	100,510		
October	454	1,516,000	70,630			178,700	3,060			3,295,000	102,098		
November	513	1,378,860	59,868			371,000	7,267			2,075,900	87,934		
December	384	1,308,300	53,172			285,500	6,540			2,916,900	116,632		
Total	4,548	25,903,060	798,728			2,359,300	42,305			44,791,820	1,158,897		
LANDED AT GLOUCESTER.													
January	91	132,630	3,078	214,562	$7,134	4,595	72	5,218	$132	303,020	5,546	545	$6
February	104	201,263	6,818	99,605	3,312	2,436	44	600	15	414,956	14,923	535	6
March	167	1,508,128	30,028	277,850	9,336	73,670	1,196	2,814	70	733,266	9,747	4,765	59
April	234	1,733,001	30,949	357,586	11,851	356,172	5,697	2,548	64	1,115,469	9,233	1,122	14
May	271	386,037	6,323	1,630,201	50,824	224,593	3,414	9,552	238	162,366	1,821	39,224	491
June	183	812,459	13,870	2,769,255	86,145	274,953	4,359	11,921	271	24,635	225	33,497	420
July	154	915,886	17,261	4,250,443	145,571	233,375	3,477	28,082	606	463,839	4,671	77,413	988
August	161	1,674,393	29,214	4,892,978	169,194	675,711	10,732	41,996	976	467,333	5,100	78,146	1,076
September	145	1,642,141	30,364	3,203,326	106,659	183,142	2,604	42,324	946	417,672	4,669	43,448	649
October	120	343,871	10,806	3,292,549	124,447	58,891	979	10,538	265	82,335	1,882	43,295	692
November	274	232,006	6,373	4,618,529	206,955	56,588	985	19,842	495	153,063	5,230	16,559	332
December	107	64,207	2,014	183,367	9,772	850	16	15,174	380	97,642	3,194	2,010	42
Total	2,011	9,646,022	187,098	25,790,251	931,200	2,144,976	33,575	190,609	4,458	4,435,596	66,241	340,559	4,775
Grand total	6,559	35,549,082	985,826	25,790,251	931,200	4,504,276	75,880	190,609	4,458	49,227,416	1,225,138	340,559	4,775
Grounds E. of 66° W. long.	701	8,219,628	185,750	22,183,297	803,149	1,702,307	27,464	108,499	2,537	4,363,626	103,802	191,378	2,740
Grounds W. of 66° W. long.	5,858	27,329,454	800,076	3,606,954	128,051	2,801,969	48,416	82,110	1,921	44,863,790	1,121,336	149,181	2,035
Landed at Boston in 1909	4,798	25,840,700	741,578			1,962,700	31,521			38,485,250	966,744		
Landed in Gloucester in 1909	1,508	12,749,431	213,569	32,744,372	1,003,653	1,185,238	18,370	185,535	4,637	3,915,516	56,275	424,603	4,289

Months.	Hake.				Pollock.				Halibut.			
	Fresh.		Salted.		Fresh.		Salted.		Fresh.		Salted.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
LANDED AT BOSTON.												
January	414,000	$12,362			531,500	$12,143			22,600	$2,721		
February	332,400	13,625			551,300	15,401			4,800	895		
March	450,600	9,902			456,000	7,548			22,000	2,521		
April	811,300	12,364			445,700	6,446			160,200	12,033		
May	1,748,500	24,920			398,100	6,003			83,000	4,113		
June	1,170,600	24,997			556,900	9,483			42,930	3,719		
July	816,800	10,923			821,500	11,710			91,708	7,565		
August	1,067,400	18,937			1,010,000	20,634			102,300	7,017		
September	3,999,800	27,538			1,008,100	24,021			56,800	7,444		
October	2,652,100	44,703			1,776,900	34,566			17,500	2,653		
November	2,273,800	39,800			1,751,100	24,648			17,300	2,504		
December	662,400	25,336			841,300	23,664			9,550	1,768		
Total	16,399,700	265,407			10,148,400	196,267			630,688	54,953		
LANDED AT GLOUCESTER.												
January	16,905	305	1,694	$17	113,620	2,521	43,405	$434	37,557	4,747	1,260	$90
February	3,930	105	285	3	810,969	15,915	11,405	136	229,789	26,821		
March	19,667	350	4,328	54	329,809	4,547	12,927	161	350,622	32,252	7,895	553
April	220,695	1,987	1,370	16	1,418,379	10,150	4,351	56	377,869	24,576	22	2
May	387,164	3,770	2,520	31	3,408,287	24,995	44,317	562	493,522	33,520	6,407	386
June	238,258	2,428	12,770	189	1,155,574	9,480	60,746	753	261,817	20,182	35,423	2,425
July	540,874	5,480	9,511	128	154,008	1,156	142,852	1,790	171,716	12,568	4,966	277
August	807,976	8,874	39,413	551	96,974	1,057	155,718	2,060	226,111	14,969	17,268	1,362
September	627,089	7,338	35,995	533	143,787	2,042	93,218	1,330	71,560	7,331	813,977	70,232
October	271,532	3,293	33,006	507	66,306	925	115,214	1,441	57,978	6,281	145,128	12,589
November	206,894	2,796	40,622	780	833,212	9,509	99,802	1,998	49,251	5,742	1,964	157
December	18,162	463	7,225	143	128,644	1,857	31,755	636	29,438	3,568	1,771	142
Total	3,359,146	37,189	188,739	2,952	8,659,569	84,154	815,710	11,357	2,357,230	192,557	1,036,081	88,215
Grand total	19,758,846	302,596	188,739	2,952	18,807,969	280,421	815,710	11,357	2,987,918	247,510	1,036,081	88,215
Grounds E. of 66° W. long	3,070,454	43,822	169,618	2,687	298,209	3,734	506,432	7,075	2,441,439	199,439	1,035,049	88,142
Grounds W. of 66° W. long	16,688,392	258,774	19,121	265	18,509,760	276,687	309,278	4,282	546,479	48,071	1,032	73
Landed at Boston in 1909	11,469,400	182,053			7,968,850	118,751			1,204,950	92,178		
Landed at Gloucester in 1909	1,693,841	11,765	113,324	1,173	4,533,741	28,312	1,380,645	15,541	2,383,685	177,828	860,113	66,471

QUANTITIES AND VALUES OF CERTAIN FISHERY PRODUCTS LANDED AT BOSTON AND GLOUCESTER, MASS., BY AMERICAN FISHING VESSELS DURING THE YEAR 1910, BY MONTHS.—Continued.

Months.	Mackerel.				Other fish.[1]				Total.				Grand total.	
	Fresh.		Salted.		Fresh.		Salted.		Fresh.		Salted.			
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
LANDED AT BOSTON.														
January									7,969,500	$207,189			7,969,500	$207,189
February									8,039,700	277,922			8,039,700	277,922
March									9,348,700	192,166			9,348,700	192,166
April									7,542,800	143,637			7,542,800	143,637
May									6,361,100	163,875			6,361,100	163,875
June	205,950	$20,207	23,200	$1,798	85,200	$5,188			6,866,680	213,560	23,200	$1,798	6,889,880	215,358
July	193,750	21,970			462,000	47,837			8,321,758	232,275			8,321,758	232,275
August	86,700	6,560	7,800	819	606,650	69,026			11,432,200	307,379	7,800	819	11,440,000	308,198
September					179,756	21,427			12,842,426	263,926			12,842,426	263,926
October					6,180	132			9,442,380	257,842			9,442,380	257,842
November									7,867,960	222,021			7,867,960	222,021
December									6,023,950	227,112			6,023,950	227,112
Total	486,400	48,737	31,000	2,617	1,339,786	143,610			102,059,154	2,708,904	31,000	2,617	102,090,154	2,711,521
LANDED AT GLOUCESTER.														
January					2,581,250	77,938	5,273,680	$91,665	3,189,577	94,207	5,540,364	99,478	8,729,941	193,685
February					925,000	27,750	578,640	11,023	2,588,343	92,376	691,070	14,495	3,279,413	106,871
March					125,000	3,750	44,228	849	3,140,162	81,870	354,807	11,082	3,494,969	92,952
April							411,800	6,413	5,221,585	82,592	778,799	18,416	6,000,384	101,008
May	17,757	1,894			14,400	326	140,000	2,800	5,094,126	76,063	1,872,221	55,332	6,966,347	131,395
June	20,643	1,485	420,600	29,957	222,000	4,355	148,000	2,825	3,010,339	56,384	3,492,212	122,985	6,502,551	179,369
July	54,772	4,211	22,800	2,280	198,271	1,476			2,732,741	50,300	4,536,067	151,640	7,268,808	201,940
August	3,168	312	12,000	2,078	161,490	2,165			4,113,156	72,423	5,237,519	177,297	9,350,675	249,720
September	60	5	7,400	1,543	104,511	1,836			3,189,962	56,189	4,239,688	181,892	7,429,650	238,081
October			86,400	11,280	2,600	364	5,800	95	883,513	24,530	3,731,930	151,316	4,615,443	175,846
November			29,400	4,079			1,347,300	24,951	1,531,014	30,635	6,174,018	239,747	7,705,032	270,382
December					950,000	33,025	6,770,660	125,319	1,288,943	44,137	7,011,962	136,434	8,300,905	180,571
Total	96,400	7,907	578,600	51,217	5,284,522	152,985	14,720,108	265,940	35,983,461	761,706	43,660,657	1,360,114	79,644,118	2,121,820
Grand total	582,800	56,644	609,600	53,834	6,624,308	296,595	14,720,108	265,940	138,042,615	3,470,610	43,691,657	1,362,731	181,734,272	4,833,341
Grounds E. of 66° W. long	67,281	5,822	563,800	48,017	4,598,468	144,707	14,714,308	265,845	24,761,412	714,540	39,472,381	1,220,192	64,233,793	1,934,732
Grounds W. of 66° W. long	515,519	50,822	45,800	5,817	2,025,840	151,888	5,800	95	113,281,203	2,756,070	4,219,276	142,539	117,500,479	2,898,609
Landed at Boston in 1909	3,521,300	196,826	490,900	25,400	1,631,600	157,917			92,084,750	2,487,568	490,900	25,400	92,575,650	2,512,968
Landed at Gloucester in 1909	599,760	27,111	2,967,000	186,751	5,485,106	122,303	9,304,664	165,428	32,546,318	655,533	47,980,256	1,447,943	80,526,574	2,103,476

[1] Includes herring from Newfoundland—4,581,250 pounds frozen, $142,463, and 14,702,308 pounds salted, $265,740.

QUANTITIES AND VALUES OF CERTAIN FISHERY PRODUCTS LANDED AT BOSTON AND GLOUCESTER, MASS., BY AMERICAN FISHING VESSELS DURING THE YEAR 1910, BY FISHING GROUNDS.

Fishing grounds.	No. of trips.	Cod.				Cusk.				Haddock.			
		Fresh.		Salted.		Fresh.		Salted.		Fresh.		Salted.	
		Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
LANDED AT BOSTON.													
East of 66° W. longitude.													
La Have Bank	30	379,000	$10,228			102,000	$1,753			681,000	$12,470		
Western Bank	29	527,400	18,007			21,860	401			662,000	20,521		
Quereau Bank	7	442,000	9,729							300	4		
Grand Bank	1												
Off Newfoundland	1												
Cape Shore	87	1,427,500	43,931			263,300	4,625			1,220,900	46,789		
Roseway Bank	2	16,000	460			20,000	250			4,000	80		
West of 66° W. longitude.													
Browns Bank	59	771,000	20,627			136,000	2,408			1,272,000	21,534		
Georges Bank	528	5,435,600	155,859			127,000	2,133			13,071,500	286,399		
Cashes Bank	23	254,000	9,209			74,000	1,231			65,600	2,364		
Clark Bank	22	184,500	5,551			2,700	33			471,000	11,415		
Fippenies Bank	3	9,300	312			16,500	240			5,000	170		
Middle Bank	578	1,288,400	52,096			310,500	6,112			3,960,400	134,251		
Jeffreys Ledge	480	850,100	35,168			350,200	7,076			2,507,950	81,507		
South Channel	676	6,796,360	204,151			131,700	2,547			13,441,000	322,066		
Nantucket Shoals	216	3,155,000	83,870			17,000	308			679,770	16,880		
Off Highland Light	34	137,600	4,966			5,500	85			322,500	11,880		
Off Chatham	196	974,100	31,338			13,800	255			2,664,300	72,080		
Shore, general	1,576	3,255,200	113,226			767,300	12,848			3,762,600	118,487		
Total	4,548	25,903,060	798,728			2,359,300	42,305			44,791,820	1,158,897		
LANDED AT GLOUCESTER.													
East of 66° W. longitude.													
La Have Bank	68	752,654	13,859	593,152	$21,183	556,681	8,962	43,429	$1,044	913,134	8,233	18,600	$274
Western Bank	101	1,563,257	33,765	3,247,312	111,262	571,648	8,892	34,905	806	333,130	6,912	62,216	898
Quereau Bank	182	2,416,434	43,072	14,295,135	513,932	123,310	1,891	20,840	511	256,872	2,685	92,742	1,263
Misaine Bank	6			734,441	27,887			90	2			1,730	35

QUANTITIES AND VALUES OF CERTAIN FISHERY PRODUCTS LANDED AT BOSTON AND GLOUCESTER, MASS., BY AMERICAN FISHING VESSELS DURING THE YEAR 1910, BY FISHING GROUNDS—Continued.

Fishing grounds.	No. of trips.	Cod.				Cusk.				Haddock.			
		Fresh.		Salted.		Fresh.		Salted.		Fresh.		Salted.	
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT GLOUCESTER—con.													
East of 66° W. longitude—Con.													
Green Bank	5	2,100	$32	13,910	$470	3,865	$62	470	$9				
Grand Bank	28	36,895	752	1,431,605	64,877			865	22			5,410	$108
St. Peters Bank	13	147,240	2,509	1,347,566	45,911			5,160	74			10,460	158
Burgeo Bank	2			1,210	36			595	15				
Bacalieu Bank	2			128,880	4,162								
Off Newfoundland	66												
Cape North	4	264,020	4,185	230,105	7,100	12,000	180						
Cape Shore	37	245,128	5,221	23,279	1,029	27,703	448	950	24	289,380	$6,021		
Gulf of St. Lawrence	20			38,720	1,210			1,195	30				
Greenland	1												
St. Anns Bank	1			80,370	3,489					2,910	87	220	4
The Gully	1			3,350	114								
Davis Strait	7			14,262	487								
West of 66° W. longitude.													
Browns Bank	66	1,303,869	23,678	392,990	14,098	299,278	4,638	25,914	628	691,804	7,587	9,265	120
Georges Bank	187	2,240,550	45,027	3,091,937	109,863	244,567	3,587	46,637	1,063	1,407,569	23,812	136,206	1,867
South Channel	1	75,060	985							2,470	27		
Nantucket Shoals	30	43,145	785	43,925	1,495	59,960	947	1,725	35	66,305	764	2,690	34
Off Chatham	1												
Bay of Fundy	1	10,630	190			11,185	168			650	7		
Seal Island	3	440	9	31,267	1,004	34,535	553	7,219	180				
South	1												
Shore, general	1,177	544,600	13,029	46,835	1,591	200,244	3,247	615	15	471,372	10,106	1,020	14
Total	2,011	9,646,022	187,098	25,790,251	931,200	2,144,976	33,575	190,609	4,458	4,435,596	66,241	340,559	4,775
Grand total	6,559	35,549,082	985,826	25,790,251	931,200	4,504,276	75,880	190,609	4,458	49,227,416	1,225,138	340,559	4,775

Fishing grounds.	Hake.				Pollock.				Halibut.			
	Fresh.		Salted.		Fresh.		Salted.		Fresh.		Salted.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
LANDED AT BOSTON.												
East of 66° W. longitude.												
La Have Bank	145,500	$3,148			22,000	$318			240,300	$20,755		
Western Bank	112,900	2,813			16,500	247			54,850	4,921		
Quereau Bank									43,300	3,670		
Grand Bank									60,000	3,600		
Off Newfoundland									45,000	1,675		
Cape Shore	617,700	13,323			78,300	1,603			49,500	6,387		
Roseway Bank	75,000	1,125			3,000	55			500	60		
West of 66° W. longitude.												
Browns Bank	50,000	958			41,000	676			62,100	5,846		
Georges Bank	570,100	12,318			311,700	6,524			49,000	4,942		
Cashes Bank	332,000	5,529			8,800	110			3,700	437		
Clark Bank	190,500	2,679			11,100	181			500	54		
Fippenies Bank	25,000	450							100	12		
Middle Bank	1,242,700	28,513			688,600	15,128			800	88		
Jeffreys Ledge	1,973,500	36,174			1,094,900	25,060			4,400	491		
South Channel	3,520,500	67,816			1,635,900	29,538			6,030	797		
Nantucket Shoals	206,800	2,943			487,000	5,982			3,708	357		
Off Highland Light	66,000	1,140			44,600	934						
Off Chatham	251,100	5,694			437,000	7,905						
Shore, general	7,020,400	80,784			5,268,000	102,006			6,900	861		
Total	16,399,700	265,407			10,148,400	196,267			630,688	54,953		
LANDED AT GLOUCESTER												
East of 66° W. longitude.												
La Have Bank	587,632	6,435	39,610	$675	39,472	342	78,796	$998	72,624	7,573	4,000	$304
Western Bank	1,015,226	11,338	53,554	832	66,688	561	121,859	1,668	109,803	8,294	10,530	887
Quereau Bank	459,921	4,886	53,329	854	63,909	521	280,465	3,997	664,246	58,465	30,173	1,961
Misaine Bank			8,540	133			6,815	120			739	58
Green Bank	2,090	22	6,670	72			550	7	45,671	5,322	15	1
Grand Bank	4,715	52	1,155	18	70	1	860	18	502,227	40,060	7,676	517
St. Peters Bank	9,625	111	2,770	36			12,237	177	144,958	9,533	1,203	65

QUANTITIES AND VALUES OF CERTAIN FISHERY PRODUCTS LANDED AT BOSTON AND GLOUCESTER, MASS., BY AMERICAN FISHING VESSELS DURING THE YEAR 1910, BY FISHING GROUNDS—Continued.

Fishing grounds.	Hake.				Pollock.				Halibut.			
	Fresh.		Salted.		Fresh.		Salted.		Fresh.		Salted.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT GLOUCESTER—continued.												
East of 66° W. longitude—Continued.												
Burgeo Bank			1,110	$14					46,546	$2,926		
Bacalieu Bank			670	10			1,320	$20			52,529	$4,480
Off Newfoundland									24,400	1,926		
Cape North	20,000	$180	115	1			130	2				
Cape Shore	20,145	389	1,990	40	8,270	$86	280	6	8,050	1,026		
Gulf of St. Lawrence									265,198	18,713	15,527	932
Greenland											141,483	12,299
St. Anns Bank			105	2			3,120	62				
The Gully									16,669	1,915		
Davis Strait									47,597	2,618	771,174	66,638
West of 66° W. longitude.												
Browns Bank	305,805	3,218	3,617	53	102,236	800	31,320	402	55,336	6,045		
Georges Bank	73,534	809	8,959	130	92,740	871	256,053	3,592	310,975	24,697	1,032	73
South Channel	8,460	93			715	5						
Nantucket Shoals	275,321	2,697			647,710	5,902	4,360	55	100	6		
Bay of Fundy	75,660	832										
Seal Island	8,710	78			135	1			37,550	2,930		
Shore, general	492,302	6,049	6,545	82	7,637,624	75,064	17,545	233	5,280	508		
Total	3,359,146	37,189	188,739	2,952	8,659,569	84,154	815,710	11,357	2,357,230	192,557	1,036,081	88,215
Grand total	19,758,846	302,596	188,739	2,952	18,807,969	280,421	815,710	11,357	2,987,918	247,510	1,036,081	88,215

Fishing grounds.	Mackerel.				Other fish.				Total.				Grand total.	
	Fresh.		Salted.		Fresh.		Salted.		Fresh.		Salted.			
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON.														
East of 66° W. longitude.														
La Have Bank					10,000	$1,386			1,579,800	$50,058			1,579,800	$50,058
Western Bank									1,395,450	46,910			1,395,450	46,910
Quereau Bank									485,600	13,403			485,600	13,403
Grand Bank									60,000	3,600			60,000	3,600
Off Newfoundland									45,000	1,675			45,000	1,675
Cape Shore	50,000	$5,000	23,200	$1,798	800	88			3,708,000	121,746	23,200	$1,798	3,731,200	123,544
Roseway Bank					1,400	154			119,900	2,184			119,900	2,184
West of 66° W. longitude.														
Browns Bank					109,300	11,526			2,441,400	63,575			2,441,400	63,575
Georges Bank	25,000	3,920	7,800	819	851,215	119,649			20,441,115	591,744	7,800	819	20,448,915	592,563
Cashes Bank									738,100	18,880			738,100	18,880
Clark Bank									860,300	19,913			860,300	19,913
Fippenies Bank									55,900	1,184			55,900	1,184
Middle Bank									7,491,400	236,188			7,491,400	236,188
Jeffreys Ledge					4,941	778			6,785,991	186,254			6,785,991	186,254
South Channel	37,500	3,900			1,300	173			25,570,290	630,988			25,570,290	630,988
Nantucket Shoals	198,750	20,430							4,748,028	130,770			4,748,028	130,770
Off Highland Light									576,200	19,005			576,200	19,005
Off Chatham	114,200	9,640			[1] 2,000	160			4,456,500	127,072			4,456,500	127,072
Shore, general	60,950	5,847			[2] 358,830	9,696			20,500,180	443,755			20,500,180	443,755
Total	486,400	48,737	31,000	2,617	1,339,786	143,610			102,059,154	2,708,904	31,000	2,617	102,090,154	2,711,521
LANDED AT GLOUCESTER.														
East of 66° W. longtiude.														
La Have Bank					2,400	336			2,924,597	45,740	777,587	24,478	3,702,184	70,218
Western Bank	12,130	485			873	102			3,672,755	70,349	3,530,376	116,353	7,203,131	186,702
Quereau Bank					575	61			3,985,267	111,581	14,772,684	522,518	18,757,951	634,099
Misaine Bank											752,355	28,235	752,355	28,235
Green Bank					1,170	117			54,896	5,555	21,615	559	76,511	6,114
Grand Bank									543,907	40,865	1,447,571	65,560	1,991,478	106,425

[1] Shad.

[2] Herring, 259,000 pounds, value $3,188; shad, 54,000 pounds, value $728; and swordfish, 45,830 pounds, value $5,780.

QUANTITIES AND VALUES OF CERTAIN FISHERY PRODUCTS LANDED AT BOSTON AND GLOUCESTER, MASS., BY AMERICAN FISHING VESSELS DURING THE YEAR 1910, BY FISHING GROUNDS—Continued.

Fishing grounds.	Mackerel.				Other fish.				Total.				Grand total.	
	Fresh.		Salted.		Fresh.		Salted.		Fresh.		Salted.			
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
LANDED AT GLOUCESTER—continued.														
East of 66° W. longitude—Continued.														
St. Peters Bank									301,823	$12,153	1,379,396	$46,421	1,681,219	$58,574
Burgeo Bank									46,546	2,926	2,915	65	49,461	2,991
Bacalieu Bank											183,399	8,672	183,399	8,672
Off Newfoundland					[1] 4,581,250	$142,463	[1] 14,702,308	$265,740	4,605,650	144,389	14,702,308	265,740	19,307,958	410,129
Cape North									296,020	4,545	230,350	7,103	526,370	11,648
Cape Shore	5,151	$337	420,600	$29,957			[1] 12,000	105	603,827	13,528	459,099	31,161	1,062,926	44,689
Gulf of St. Lawrence			120,000	16,262					265,198	18,713	175,442	18,434	440,640	37,147
Greenland											141,483	12,299	141,483	12,299
St. Anns Bank									2,910	87	83,815	3,557	86,725	3,644
The Gully									16,669	1,915	3,350	114	20,019	2,029
Davis Strait									47,597	2,618	785,436	67,125	833,033	69,743
West of 66° W. longitude.														
Browns Bank					319	35			2,758,647	46,001	463,106	15,301	3,221,753	61,302
Georges Bank					639	59			4,370,574	98,862	3,540,824	116,588	7,911,398	215,450
South Channel									86,705	1,110			86,705	1,110
Nantucket Shoals	49,539	4,234	26,400	2,573	[2] 30,600	819			1,172,680	16,154	79,100	4,192	1,251,780	20,346
Off Chatham			8,400	1,785							8,400	1,785	8,400	1,785
Bay of Fundy									98,125	1,197			98,125	1,197
Seal Island									81,370	3,571	38,486	1,184	119,856	4,755
South	17,757	1,894							17,757	1,894			17,757	1,894
Shore, general	11,823	957	3,200	640	[3] 666,696	8,993	[1] 5,800	95	10,029,941	117,953	81,560	2,670	10,111,501	120,623
Total	96,400	7,907	578,600	51,217	5,284,522	152,985	14,720,108	265,940	35,983,461	761,706	43,660,657	1,360,114	79,644,118	2,121,820
Grand total	582,800	56,644	609,600	53,834	6,624,308	296,595	14,720,108	265,940	138,042,615	3,470,610	43,691,657	1,362,731	181,734,272	4,833,341

[1] Herring.
[2] Shad.
[3] Bluebacks, 198,067 pounds, value $1,404; butterfish, 65,871 pounds, value $1,466; herring, 153,300 pounds, value $2,967; shad, 43,096 pounds, value $1,042; swordfish, 8,329 pound value $1,188; and whiting or silver hake, 198,033 pounds, value $926. All other items under "Other fish" are swordfish.

Of the fishery products landed at Boston and Gloucester by American fishing vessels during the year, 64.53 per cent of the quantity and 59.84 per cent of the value were from fishing grounds lying off the coast of the United States. About 22 per cent of the quantity and 26 per cent of the value were from fishing banks off the coast of the Canadian Provinces, and 13.33 per cent of the quantity and 13.81 per cent of the value were from grounds off the coast of Newfoundland. A trip of halibut amounting to 141,483 pounds, valued at $12,299, was taken off the coast of Greenland. The Newfoundland herring fishery furnished 10.61 per cent of the quantity and 8.44 per cent of the value of the products of the vessel fisheries of these ports. The catch from each of these fishing regions is given by species in the following table:

QUANTITY AND VALUE OF FISH LANDED BY AMERICAN FISHING VESSELS AT BOSTON AND GLOUCESTER, MASS., IN 1910, FROM GROUNDS OFF THE COASTS OF THE UNITED STATES, NEWFOUNDLAND, AND CANADIAN PROVINCES.

Species.	United States.		Newfoundland.[1]		Canadian Provinces.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Cod:								
Fresh	27,318,384	$799,877	186,235	$3,293	8,044,463	$182,656	35,549,082	$985,826
Salted	3,575,687	127,047	2,937,433	115,943	19,277,131	688,210	25,790,251	931,200
Cusk:								
Fresh	2,756,249	47,695	3,865	62	1,744,162	28,123	4,504,276	75,880
Salted	74,891	1,741	7,090	120	108,628	2,597	190,609	4,458
Haddock:								
Fresh	44,863,140	1,121,329			4,364,276	103,809	49,227,416	1,225,138
Salted	149,181	2,035	15,870	266	175,508	2,474	340,559	4,775
Hake:								
Fresh	16,604,022	257,864	16,430	185	3,138,394	44,547	19,758,846	302,596
Salted	19,121	265	12,375	150	157,243	2,537	188,739	2,952
Pollock:								
Fresh	18,509,625	276,686	70	1	298,274	3,734	18,807,969	280,421
Salted	309,278	4,282	14,967	222	491,465	6,853	815,710	11,357
Halibut:								
Fresh	508,929	45,141	916,399	67,660	1,562,590	134,709	2,987,918	247,510
Salted	1,032	73	974,080	84,000	60,969	4,142	1,036,081	88,215
Mackerel:								
Fresh	515,519	50,822			67,281	5,822	582,800	56,644
Salted	45,800	5,817			563,800	48,017	609,600	53,834
Herring:								
Fresh	412,300	6,155	4,581,250	142.463			4,993,550	148,618
Salted	5,800	95	14,702,308	265,740	12,000	105	14,720,108	265,940
Swordfish:								
Fresh	54,159	6,968					54,159	6,968
Other fish:								
Fresh	1,559,381,	138,765	1,170	117	16,048	2,127	1,576,599	141,009
Total	117,282,498	2,892,657	24,369,542	680,222	40,082,232	1,260,462	181,734,272	4,833,341

[1] Includes 141,483 pounds of salted halibut from Greenland, valued at $12,299.

MASSACHUSETTS FLATFISH FISHERY.

In connection with the very extensive operations of the Bureau addressed to the hatching of the American flatfish or winter flounder (*Pseudopleuronectes americanus*) at the stations at Gloucester and Woods Hole, Mass., it is interesting to note the marked development of the Massachusetts flatfish fishery and the great commercial importance the species has recently attained.

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In 1880 the yield of all flatfish except halibut in the Massachusetts fisheries was 571,470 pounds, for which the fishermen received $8,572. Nine years later the product had risen to 957,773 pounds, worth $20,966. In 1905 the fishermen marketed about 4,000,000 pounds, for which they received over $97,800, while in 1908 they are credited with over 7,000,000 pounds, valued at $146,000. The bulk of the flatfish consists of the winter flounder, and the most important fishery now is that conducted on Cape Cod with beam and otter trawls, which apparatus have been chiefly responsible for the recent development of the fishery.

The practical bearings of flatfish hatching have been specially noteworthy on the southern side of Cape Cod in waters that are directly influenced by the work of the Woods Hole station, from which an average of 150,000,000 flatfish have been planted annually during the past 10 years. For several seasons prior to 1908 there had been a limited hand-line fishery for winter flounders at Hyannis. The increasing abundance of fish in that vicinity resulted in the introduction of power boats equipped with beam trawls, and their success was so great that the fleet was rapidly augmented and the fishery has now been extended to Falmouth, a few miles from Woods Hole. Previous to 1908 from 6 to 12 small boats employing hand lines made an aggregate annual catch of 200 to 300 barrels. With the introduction of beam trawls, more than 125 men have gone into the business in Hyannis and Falmouth, and in the season of 1910–11 they caught and marketed 11,500 barrels (over 2,575,000 pounds) of winter flounder, receiving therefor the sum of $57,500.

The existence of this fishery, its rapid growth, and its increasing importance are generally regarded as evidence of the hatchery work.

NEWFOUNDLAND HERRING FISHERY.

The herring fishery carried on by American vessels on the west coast of Newfoundland during the season of 1910–11 was conducted in the usual manner from the middle of October to the 20th of January. The fleet included 71 vessels, one of which was lost on the home passage with all on board. In addition to these 3 Canadian vessels were chartered to bring cargoes of herring. Second trips were made by 18 vessels, few, if any, of which secured full cargoes. One vessel on the second trip returned without any cargo, and one, failing to secure herring, loaded with salted cod.

In the early part of the season herring were more plentiful at Bonne Bay than at Bay of Islands, but were small in size compared to those usually taken at Bay of Islands. The greater part of the catch, however, was obtained at Bay of Islands, although herring were not abundant there at any time during the season. This fact, together with the prevalent stormy weather, reduced the catch far

below what was expected, considering the size of the fleet. The weather from January 19 to 21 was unusually severe, causing all the arms of the bay to freeze over and forcing most of the fleet to sea to escape the ice. Four vessels were caught in the ice, one partly loaded with frozen herring, which were shipped by rail to Port aux Basques and there placed on board an American vessel.

Four of the vessels that were forced out of Bay of Islands on account of the ice proceeded to Port aux Basques, while their captains and agents remained at Birchy Cove for the purpose of taking herring through the ice in the Humber Arm, employing the fishermen engaged earlier in the season. The catch was shipped by rail to Port aux Basques and placed on board the vessels. In this way the vessels were quickly loaded, demonstrating that when the arms of the bay are frozen over and herring are plentiful in the Humber it is possible to load a portion of the fleet at Port aux Basques. The Newfoundland herring taken by the American fleet during the season amounted to about 5,925,373 pounds fresh frozen and 14,722,148 pounds salted. In 1910 only two Canadian vessels were engaged in the herring fishery at Bay of Islands. In 1909 a small body of herring was reported in Fortune Bay, which was the first appearance of this species in that locality for many years; during the season of 1910–11 there was a considerable run of herring in all parts of the bay, and several Canadian vessels obtained cargoes there.

PACIFIC HALIBUT FISHERY.

In continuation of work conducted many years ago in the interests of the commercial fisheries of the Pacific coast, the Bureau in May, 1911, began an investigation of Alaskan fishing grounds with the special object of securing information regarding the resources of the halibut banks, and of discovering, if possible, new fishing grounds for this important species. The steamer *Albatross* was detailed for this survey, and the chief of the division of fisheries was placed in charge of the inquiry, which meets with the hearty support of the fishing interests of Washington and Alaska. The ship was provided with fishermen, supplies, and such fishing apparatus as would be necessary in successfully conducting experiments for determining the location and abundance of halibut.

The halibut fishery of the Pacific coast was reported to have been more extensive and successful in 1910 than in any previous year in the history of the industry, the catch of halibut for the entire coast amounting to over 53,000,000 pounds, of which about 30,500,000 pounds were handled at ports on Puget Sound and the remaining 22,500,000 pounds in British Columbia. The output would, no doubt, have been even larger than this except for the bad weather, poor fishing, and scarcity of bait in the latter part of the year. In the

early months of the year the fleet met with good success on the recently discovered banks off North Island, just north of Graham Island, and also on other fishing grounds. Later in the spring large catches were taken on the Goose Island banks. In the summer months fish were abundant in many localities, and the fleet covered a wide range of territory, including Cape Scott, Sydney Inlet, off Flattery, and up the west shore of Vancouver Island. The fleet consisted of about 60 steamers and schooners, in addition to which a large number of boats of a smaller type engaged in the industry in Alaskan waters. There was also a large local fleet of vessels and boats fishing from Alaskan ports. In the past few years the halibut fishery of the Pacific coast has increased in importance until it now ranks second only to the salmon industry.

FLORIDA SPONGE LAW.

In the Bureau's report for the preceding fiscal year there were pointed out certain defects militating against the efficient enforcement of the act of June 20, 1906, for the protection of the sponge fisheries on the high seas adjacent to the coast of Florida. It is not necessary again to indicate these defects in detail, but the experience of the past year has emphasized their importance. Breaches of the law have been flagrant and numerous. At the end of the fiscal year it came to the knowledge of the Bureau that a fleet of about 15 vessels—some reports stated the number at 30—were engaged in the illicit diving for sponges during the close season, and that quantities of sponges smaller than the legal minimum size were being placed on the market.

With the appropriation, which became available on July 1, for the enforcement of the act during the fiscal year 1912, it is hoped that the illegal practices may be curbed, but the form of the law makes the attempt unnecessarily difficult. It is believed that the law should be speedily amended so as to minimize the difficulty and expense of enforcement. The Bureau also believes that the close season should be shortened, as the present five months of idleness is wasteful of capital and demoralizing to labor. To compensate for the additional drain which this would impose on the sponge beds, the minimum size limit of sponges which can be legally taken should be raised from 4 inches to 5 inches. These measures taken together are both economically and biologically justifiable from every viewpoint.

INTERNATIONAL FISHERY AFFAIRS.

NORTH ATLANTIC FISHERIES DISPUTE AND ARBITRATION.

The Bureau has for many years been more or less involved in the fishery questions arising in connection with the operations of American fishermen on the shores of Newfoundland, Labrador, Magdalen

Islands, and other parts of the British maritime Provinces under the treaty of 1818. Under the terms of an agreement signed at Washington on January 27, 1909, by representatives of the British and United States Governments, it was decided to submit to the permanent court of arbitration at The Hague the principal questions that have arisen in connection with the interpretation of that treaty; and it is a cause for congratulation that this long-standing dispute has now been settled by arbitration.

In view of the importance and historical interest of this subject, a brief review of its principal features may appropriately be given in this report.

The treaty of peace between the United States and Great Britain, in 1783, had as its third article the following:

> It is agreed that the people of the United States shall continue to enjoy unmolested the right to take fish of every kind on the Grand Bank, and on all the other banks of Newfoundland; also in the Gulph of Saint Lawrence and at all other places in the sea where the inhabitants of both countries used at any time heretofore to fish. And also that the inhabitants of the United States shall have liberty to take fish of every kind on such part of the coast of Newfoundland as British fishermen shall use (but not to dry or cure the same on that island) and also on the coasts, bays and creeks of all other of His Britannic Majesty's dominions in America; and that the American fishermen shall have liberty to dry and cure fish in any of the unsettled bays, harbours and creeks of Nova Scotia, Magdalen Islands and Labrador, so long as the same shall remain unsettled; but so soon as the same or either of them shall be settled, it shall not be lawful for the said fishermen to dry or cure fish at such settlements, without a previous agreement for that purpose with the inhabitants, proprietors or possessors of the ground.

After the close of the War of 1812 the question arose as to whether the fishery provisions of the treaty of 1783 had been abrogated by the war. Great Britain contended that this part of the treaty was no longer in force, but the United States refused to agree to such a contention. With the two Governments thus assuming opposite views on the question, the prosecution of the fisheries necessarily led to more or less serious conflicts of authority and protracted diplomatic conference and correspondence, the outcome of which was the negotiation and adoption in 1818 of a new treaty. The important article of this treaty was as follows:

> Whereas differences have arisen respecting the Liberty claimed by the United States for the inhabitants thereof, to take, dry and cure fish on Certain Coasts, Bays, Harbours, and Creeks of His Britannic Majesty's Dominions in America, it is agreed between the High Contracting Parties, that the inhabitants of the said United States shall have forever, in common with the Subjects of His Brittanic Majesty, the Liberty to take fish of every kind on that part of the Southern Coast of Newfoundland which extends from Cape Ray to the Rameau Islands, on the Western and the Northern Coast of Newfoundland, from the said Cape Ray to the Quirpon Islands, on the shores of the Magdalen Islands, and also on the Coasts, Bays, Harbours and Creeks from Mount Joly on the

Southern Coast of Labrador, to and through the Straits of Belleisle and thence Northwardly indefinitely along the Coast, without prejudice, however, to any of the exclusive Rights of the Hudson Bay Company: And that the American fishermen shall have liberty forever, to dry and cure fish in any of the unsettled Bays, Harbours and Creeks of the Southern part of the Coast of Newfoundland hereabove described, and of the Coast of Labrador; but so soon as the same or any portion thereof, shall be settled it shall not be lawful for the said Fishermen to dry or cure Fish at such Portion so settled, without previous agreement for such purpose with the Inhabitants, Proprietors, or Possessors of the ground. And the United States hereby renounce forever, any Liberty, heretofore enjoyed or claimed by the Inhabitants thereof, to take, dry or cure Fish on, or within three marine Miles of any of the Coasts, Bays, Creeks or Harbours of His Britannic Majesty's Dominions in America not included within the above-mentioned limits: Provided, however, that the American Fishermen shall be admitted to enter such Bays, or Harbours for the purpose of Shelter and of repairing Damages therein, or purchasing Wood, and of obtaining Water, and for no other purpose whatever. But they shall be under such restrictions as may be necessary to prevent their taking, drying or curing Fish therein, or in any other manner whatever abusing the Privileges hereby reserved to them.

While the object of this treaty was the clear definition of the rights of United States fishermen on the coasts of Canada and Newfoundland, it afterwards transpired that those rights were still unsettled and uncertain; and for over 90 years this matter remained a source of annoyance, contention, bad feeling, and conflict, until the responsible authorities of the two nations chose an opportune time and arranged for the settlement that happily has now been consummated.

The arbitration proceedings began at The Hague on June 1, 1910, and continued until September 7, 1910, when the award was announced. The court, by agreement, consisted of five members of the permanent court of arbitration at The Hague; and to it were submitted for final decision the following questions, which covered all the main points in dispute:

Question 1. To what extent are the following contentions or either of them justified?

It is contended on the part of Great Britain that the exercise of the liberty to take fish referred to in the said article, which the inhabitants of the United States have forever in common with the subjects of His Britannic Majesty, is subject, without the consent of the United States, to reasonable regulation by Great Britain, Canada, or Newfoundland in the form of municipal laws, ordinances, or rules, as, for example, to regulations in respect of (1) the hours, days, or seasons when fish may be taken on the treaty coasts; (2) the method, means, and implements to be used, in the taking of fish or in the carrying on of fishing operations on such coasts; (3) any other matters of a similar character relating to fishing; such regulations being reasonable, as being, for instance—

(*a*) Appropriate or necessary for the protection and preservation of such fisheries and the exercise of the rights of British subjects therein and of the liberty which by the said Article I the inhabitants of the United States have therein in common with British subjects;

(*b*) Desirable on grounds of public order and morals;

(*c*) Equitable and fair as between local fishermen and the inhabitants of the United States exercising the said treaty liberty and not so framed as to give unfairly an advantage to the former over the latter class.

It is contended on the part of the United States that the exercise of such liberty is not subject to limitations or restraints by Great Britain, Canada, or Newfoundland in the form of municipal laws, ordinances, or regulations in respect of (1) the hours, days, or seasons when the inhabitants of the United States may take fish on the treaty coasts, or (2) the method, means, and implements used by them in taking fish or in carrying on fishing operations on such coasts, or (3) any other limitations or restraints of similar character—

(*a*) Unless they are appropriate and necessary for the protection and preservation of the common rights in such fisheries and the exercise thereof; and

(*b*) Unless they are reasonable in themselves and fair as between local fishermen and fishermen coming from the United States, and not so framed as to give an advantage to the former over the latter class; and

(*c*) Unless their appropriateness, necessity, reasonableness, and fairness be determined by the United States and Great Britain by common accord and the United States concurs in their enforcement.

Question 2. Have the inhabitants of the United States, while exercising the liberties referred to in said article, a right to employ as members of the fishing crews of their vessels persons not inhabitants of the United States?

Question 3. Can the exercise by the inhabitants of the United States of the liberties referred to in the said article be subjected, without the consent of the United States, to the requirements of entry or report at customhouses or the payment of light or harbor or other dues, or to any other similar requirement or condition or exaction?

Question 4. Under the provision of the said article that the American fishermen shall be admitted to enter certain bays or harbors for shelter, repairs, wood, or water, and for no other purpose whatever, but that they shall be under such restrictions as may be necessary to prevent their taking, drying, or curing fish therein or in any other manner whatever abusing the privileges thereby reserved to them, is it permissible to impose restrictions making the exercise of such privileges conditional upon the payment of light or harbor or other dues, or entering or reporting at customhouses or any similar conditions?

Question 5. From where must be measured the "three marine miles of any of the coasts, bays, creeks, or harbors" referred to in the said article?

Question 6. Have the inhabitants of the United States the liberty under the said article or otherwise to take fish in the bays, harbors, and creeks on that part of the southern coast of Newfoundland which extends from Cape Ray to Rameau Islands, or on the western and northern coasts of Newfoundland from Cape Ray to Quirpon Islands, or on the Magdalen Islands?

Question 7. Are the inhabitants of the United States whose vessels resort to the treaty coasts for the purpose of exercising the liberties referred to in Article I of the treaty of 1818 entitled to have for those vessels, when duly authorized by the United States in that behalf, the commercial privileges on the treaty coasts accorded by agreement or otherwise to United States trading vessels generally?

The presentation of the contentions, views, and claims of the two nations was submitted to the court in printed form before the formal opening, and was of a most elaborate character. The agent on behalf of the United States prepared for the information of the court six volumes embodying "The Case of the United States," with two appendixes, "The Counter Case of the United States," with appendix,

and "The Argument of the United States," the series comprising over 2,500 printed pages. A similar duty devolved on the agent for Great Britain and the amount of matter thus prepared was about equal to that for the United States.

The principal part of the proceedings was taken by the oral argument, which consumed 40 sessions and was delivered by four of the counsel for Great Britain and four for the United States. The concluding arguments were by Sir William Robson, Attorney General of Great Britain, and Senator Elihu Root, who was the chief counsel for the United States and was the Secretary of State under whom the negotiations for arbitration were concluded.

The most important matter coming before the tribunal and covered by the award was that represented by question 1, inasmuch as the sovereignty of Great Britain was involved on one hand and the practical exercise of the fishing rights by Americans on the other. The tribunal therefore went most deeply into the controversy, and rendered an opinion that was in a measure a compromise. The substance of the award is as follows:

(1) The right of Great Britain to make regulations without the consent of the United States, as to the exercise of the liberty to take fish under the treaty, in the form of municipal laws, ordinances, or rules of Great Britain, Canada, or Newfoundland is inherent in the sovereignty of Great Britain; (2) in the exercise of that liberty the regulations must be made bona fide and must not be in violation of the treaty; (3) such regulations must be (*a*) appropriate or necessary for the protection and preservation of the fisheries, or (*b*) desirable or necessary on grounds of public order or morals without unnecessarily interfering with the fishery itself, and (*c*) equitable and fair as between local and American fishermen, and not so framed as to give unfairly an advantage to the former over the latter class; (4) in case of a difference of opinion between the two nations as to the reasonableness of any existing fishery regulation made by Great Britain, Canada, or Newfoundland, the decision must be made by an impartial commission of expert specialists, in accordance with the terms of the special agreement, the commission to consist of one nonnational member to be designated by the court and of one member to be designated within one month by each of the parties to the arbitration; (5) the unanimous opinion of this commission or the opinion of the nonnational member in case of dispute is recommended for acceptance of the parties, in lieu of a reconvening of the court; (6) all future municipal laws, ordinances, or rules for the regulation of the fishery in respect to (*a*) the hours, days, or seasons when fish may be taken on the treaty coasts, (*b*) the methods, means, and implements used in taking fish or in conducting fishing operations, (*c*) any other matters of a similar character, shall be published in the respective official gazettes of Great Britain, Canada, or Newfoundland at least two months before becoming effective; (7) if the United States Government considers any such laws or regulations inconsistent with the treaty of 1818, they shall not come into effect so far as the inhabitants of the United States are concerned until approved by a permanent mixed fishery commission, composed of one expert on behalf of the United States, one on behalf of Canada, and one on behalf of Newfoundland, together with an umpire commissioner to be named by the two nations or, in the event of their failure to agree, by the Queen of the Netherlands.

In accordance with the terms of this part of the award, the court named as the nonnational member of the expert commission to pass on the existing fishery laws and regulations Dr. P. P. C. Hoek, scientific fishery adviser of the Dutch Government, and within the time specified the British Government named as its representative Hon. Donald Morison, minister of justice of Newfoundland, and the United States Government nominated Dr. Hugh M. Smith, deputy fish commissioner.

The principal issue in question 2 was whether American fishing vessels intending to operate on the treaty coasts might sail from the home port with skeleton crews and then take on board in Canadian or Newfoundland ports enough men to fill out their complement. The award was that inhabitants of the United States, while exercising their liberties under the treaty, have the right to employ, as members of the fishing crews of their vessels, persons not inhabitants of the United States; but, in order to prevent any misunderstanding as to the effects of its award, the court expressed the opinion that noninhabitants employed as members of the fishing crews of United States vessels derive no benefit or immunity from the treaty.

With regard to question 3 the tribunal decided that the requirement that an American fishing vessel, while exercising its rights under the treaty, should report at the customhouse is not unreasonable, but there should be no such requirement unless there be reasonably convenient opportunity afforded to report in person or by telegraph either at a customhouse or to a customs official; and that the exercise of the fishing liberty should not be subjected to the purely commercial formalities of report, entry, and clearance at a customhouse, nor to light, harbor, or other dues not imposed upon Newfoundland fishermen.

Question 4 is closely related to question 3, and the award thereunder follows the same lines. The tribunal held that the provision of the treaty of 1818 admitting American fishermen to enter certain bays or harbors for shelter, repairs, wood and water, and for no other purpose whatever, is an exercise of those duties of hospitality and humanity which all civilized nations impose upon themselves and expect the performance of from others; that the enumerated purposes for which entry is permitted all relate to the exigencies in which those who pursue their perilous calling on the sea may be involved; and that to impose restrictions making the exercise of such privileges conditional upon the payment of light, harbor, or other dues, or entering or reporting at customhouses, or any other similar conditions, would be inconsistent with the grounds on which the privileges rest, and therefore is not permissible. The tribunal further held, however, in order that these privileges should not be abused, that American fishermen availing themselves thereof should not

remain in such bays or harbors for a longer period than 48 hours without reporting, either in person or by telegraph, at a customhouse or to a customs official, if reasonably convenient opportunity therefor is afforded, and if such course is thought necessary by Great Britain or the colonial governments.

A very interesting and important international question that has caused considerable friction between the United States and Canada is the proper way in which to measure the 3-mile limit with respect to bays. Question 5 was therefore one of the major subjects coming before the tribunal. The general principle laid down in the award is that the 3 marine miles are to be measured in a straight line drawn across the body of water at the place where it ceases to have the configuration and characteristics of a bay, and at all other places the 3 marine miles are to be measured following the sinuosities of the coast. The extreme position taken by Great Britain, that bays are to be defined by lines drawn from headland to headland, was not sustained, but the contention of the United States, that in the absence of other expressed and acknowledged claims of sovereignty bays are to be regarded as indentations which are 6 miles or less in width at their mouth, or are to be regarded as beginning where the sides of the indentations approach within 6 miles of each other, was likewise overruled. For certain bays (for example, Chaleur, Miramichi, Egmont, and St. Ann's, in Canada, and Fortune, in Newfoundland) "where the configuration of the coast and the local climatic conditions are such that foreign fishermen when within the geographical headlands might reasonably and bona fide believe themselves on the high seas," the limits of exclusion are specifically defined in the award; for all other bays "the limits of exclusion shall be drawn 3 miles seaward from a straight line across the bay in the part nearest the entrance, at the first point where the width does not exceed 10 miles."

Question 6, submitted at the request of the Newfoundland Government and addressed to the vital point whether American fishermen are entitled to the liberties they have always enjoyed of taking fish in the bays, harbors, and creeks on the coasts of Newfoundland and on the Magdalen Islands, was decided in favor of the United States. This decision is very important, for the reason that the Newfoundland Government, in the event of an award favorable to its contention, was preparing to present a claim for large damages for the value of all the cod, halibut, herring, etc., taken by American vessels in the bays of that colony during the past 90 years.

The final question took cognizance of certain practices of American fishermen on the coast of Newfoundland. The tribunal held that inhabitants of the United States, when resorting to the treaty coasts for the purpose of exercising their fishing rights, may, when duly

authorized by the United States, also enjoy the commercial privileges accorded to United States vessels generally, provided that the liberty of fishing and the privilege of trading are not exercised concurrently.

It is a noteworthy fact that the award on all the weighty matters involved was unanimous, with the exception that one member of the court rendered a dissenting opinion on the fifth question.

At the request of the Department of State, the deputy commissioner and the assistant in charge of the division of fisheries of this Bureau were in attendance at The Hague during the continuance of the arbitration proceedings.

FUR-SEAL NEGOTIATIONS.

An international conference was convened in Washington on May 5, 1911, for the purpose of concluding a treaty affecting the fur seals of the North Pacific Ocean. The conference was held under the auspices of the Department of State and was attended by representatives of all the nations having sealing interests in the region named, that is, Great Britain, Russia, Japan, and the United States. The plenipotentiaries on the part of this country were the Secretary of Commerce and Labor and the Counsellor of the Department of State, the former being the president of the conference. The meetings continued until July 7, 1911, when a treaty was signed under the terms of which all pelagic sealing by citizens or subjects of the signatory powers will be prohibited for a period of 15 years, leaving to the respective Governments having fur-seal islands the right to deal independently with the question of killing on land.

In order, however, to compensate for pelagic sealing interests thus destroyed, the United States agrees to give to Great Britain (Canada) 15 per cent and to Japan 15 per cent of the sealskins obtained each year on the Pribilof Islands; Russia makes similar provision with reference to the seals taken on the Commander Islands; and Japan assigns 10 per cent of her sealskins taken on Robben Reef and the Kuril Islands to each of the other three nations.

Other provisions of the treaty are: (1) The advance payment by the United States to Great Britain and Japan of $200,000 each, these cash payments to be credited in lieu of sealskins due; (2) if no seals are killed on the Pribilof Islands during any year when the herd numbers 100,000 or more, the United States must pay $10,000 to Great Britain and a like sum to Japan for such year. A special article accords to the sea otter the same protection in extraterritorial waters that the fur seal receives.

The treaty was ratified by the Senate on July 24 and became effective on December 15, 1911. The effects of this agreement on the sadly

depleted seal herds of the United States, Russia, and Japan can not fail to be salutary. For the first time the seals receive an adequate measure of protection that all experience and observation have shown to be necessary for the prevention of commercial extinction.

FISHERIES OF BOUNDARY WATERS OF UNITED STATES AND CANADA.

Reference has been made in previous reports to the treaty between the United States and Great Britain, signed April 11, 1908, which provided for the appointment of two international fisheries commissioners with power to draw up a set of uniform and common regulations for the protection and preservation of the food fishes in the boundary waters between the United States and Canada.

After very comprehensive field investigations by the commissioners, assisted by the Bureau of Fisheries, during which every fishery and practically every fishing ground from Passamaquoddy Bay to Vancouver Island were covered, the commissioners made their report, which on February 2, 1910, was transmitted to Congress by the President in order that legislative action necessary for the enforcement of the regulations might be taken.

On May 22, 1911, a bill passed the Senate giving the force and effect of law on the United States side of the boundary line to all the regulations except ten. Unfortunately, those from which approval was withheld are most vitally important to the preservation of the most valuable fisheries in international waters, namely, the waters of Puget Sound and Lake Erie; and this action has had the effect of vitiating the treaty, as Canada, it is understood, will decline to accept the treaty with the regulations in question omitted.

INTERNATIONAL COOPERATION IN FISHERY WORK.

The United States Government, as represented by the Department of Commerce and Labor and the Bureau of Fisheries, has been officially invited to become a member of the International Council for the Exploration of the Sea. This organization, founded in 1902, with permanent headquarters in Copenhagen, is composed of official delegates of most of the nations of western Europe, and has for its chief object the prosecution of biological and physical investigations of the sea in the interests of the fishing industry. The council acts as the adviser of the affiliated nations in matters pertaining to the sea fisheries and is accumulating a vast fund of facts to be applied in the consideration of national and international fishery questions affecting the preservation of the fish supply.

The acceptance of this invitation is strongly advocated, and the Department of State has included in the estimates for foreign intercourse for the fiscal year 1913 an item covering the pro rata share

of the United States in the administrative and other expenses of the council.

Practically all the important fishery problems that are demanding attention in Europe are similar to or identical with those which have already come up or are destined to arise on the western shores of the Atlantic, and, in fact, along our entire coast. It will be of the greatest advantage to the United States as a whole and to each of the seaboard States if this country is able to participate in and profit directly by the studies conducted by the leading fishery authorities and experts of western Europe, and the saving of much time and expense will result from this cooperation. It is therefore hoped that Congress will grant the necessary authority.

FIFTH INTERNATIONAL FISHERY CONGRESS.

The United States was represented by a scientific assistant of the Bureau of Fisheries at the Fifth International Fishery Congress, which was held in Rome in May, 1911, in connection with the celebration of the fiftieth anniversary of the unification of Italy. There were about 350 members in attendance, and about 30 countries were represented by official delegates, among whom were many of the leading authorities of the world in matters relating to the fisheries.

Of the objects of international interest discussed by the congress, that relating to the regulation of the sponge fisheries was of the most concern to the United States. Both in this country and in the Mediterranean the best and most prolific sponge beds are outside the limits of ordinary territorial jurisdiction, and they therefore present special difficulties in policing. An important act of the congress was the provision of a special committee to arrange and coordinate the discussions of subjects of international importance. Ostend, Belgium, was selected as the place for the next session of the congress, which will be held in 1913.

FOREIGN FISHERY INQUIRIES.

At the request of the Department of State, a representative of the Bureau was detailed to visit Newfoundland to observe the operations of American vessels engaged in the herring fishery on the west coast of the island under the provisions of the treaty of 1818. The detail extended from November 20, 1910, to February 28, 1911. This was the sixth year in which a similar detail has been made. No vessel was assigned to the work either this year or last, the representative making headquarters on shore and visiting the various localities by the regular means of transportation.

In connection with the detail of Bureau assistants at The Hague on the occasion of the arbitration proceedings relative to the North

Atlantic fisheries dispute, opportunity was afforded for inspection and study of certain fisheries and fishery industries of Holland, England, and other countries bordering on the North Sea.

Taking advantage of the attendance of an assistant as representative of the United States at the Fifth International Fishery Congress, held in Rome, Italy, an investigation was made of the extent, condition, and methods of the sponge fisheries of Tunisia and Tripoli. The methods do not differ essentially from those now employed in the United States, and many of the problems presented are the same as those confronting the industry in this country. Experiments in sponge culture carried on at a Government laboratory at Sfax, Tunisia, confirm experiments carried on by this Bureau in Florida, although the present economic outlook is less promising. It is understood that further work is to be conducted upon lines not divulged.

MISCELLANEOUS ADMINISTRATIVE MATTERS.

NEW STATIONS AND IMPROVEMENTS.

By authority of Congress 6.14 acres of land formerly leased by the Bureau were purchased for the use of the Clackamas (Oreg.) station. This property is favorably located on the Clackamas River and is already equipped with a hatchery and other buildings.

Under authority of the act to provide for two or more new salmon-culture stations on Puget Sound or its tributaries, land has been acquired as follows: At Birdsview, Wash., where a substation had been operated in connection with the Baker Lake station for several years, a tract of 10 acres was purchased for $500, and 15 acres adjoining, needed to protect the water supply, was acquired for $600. On the Duckabush River, a tributary of Hood Canal, 10 acres were obtained at a cost of $250; and on the Quilcene River, also a tributary of Hood Canal, 10 acres were acquired by condemnation proceedings. Steps were at once taken to develop these properties, which are chiefly for salmon propagation. Hatcheries and other necessary buildings have been erected at Duckabush and Quilcene, and these stations are ready for eggs when the season opens. Work at Birdsview is now in progress.

At Fairport, Iowa, and Homer, Minn., construction has proceeded satisfactorily, there having been built at the former station a large settling reservoir, three cottages for employees, besides ponds and water supply and drainage systems. At Homer two cottages, a laboratory, and a pump house have been added to the plant, and the station is ready for active fish-cultural and biological work.

At the new auxiliary station at Holden, Vt., a dam was built to form a natural reservoir, pipe line and ponds were prepared, and a hatchery was erected.

At other stations for which there are special appropriations buildings and ponds have been constructed or repaired, water systems have been extended, and other improvements tending to enhance efficiency and increase facilities have been made.

The sundry civil bill approved March 4, 1911, authorized new fish-cultural stations in the States of Wyoming and South Carolina and in Jefferson County, Ky. An act approved March 1, 1911, authorized a marine biological station on the Gulf coast of Florida, provided that State donates to the United States the necessary land and water rights. Investigations will be undertaken as soon as practicable with a view to selecting sites for these stations.

MOVEMENTS OF VESSELS.

During the summer of 1910 the steamer *Albatross* was placed at the disposal of the Secretary, who, accompanied by the Attorney General, visited Alaska for the purpose of inspecting the Government activities in which the Department of Commerce and Labor is interested, including the seal fisheries of the Pribilof Islands. The latter part of the winter and early spring were occupied by a scientific expedition to the Gulf of California in cooperation with the American Museum of Natural History; and in May, 1911, the vessel sailed from San Francisco for the purpose of conducting an investigation of certain of the halibut and cod grounds of the North Pacific Ocean.

At the beginning of the fiscal year the steamer *Fish Hawk* was engaged in an oyster survey in Delaware River and Bay, and on the conclusion of this work went to Woods Hole for service in connection with the scientific work of the laboratory at that place. During the winter the vessel was utilized in a survey of the oyster grounds of Alabama and Mississippi, operating chiefly in Mississippi Sound. As the *Fish Hawk* was in need of extensive repairs, on her return from the Gulf waters arrangements were made for a thorough refitting.

The schooner *Grampus* was engaged as usual in fish-cultural work for the marine stations on the New England coast, and the other vessels of the Bureau were utilized for the same purpose in connection with the several stations to which they are attached.

PUBLICATIONS AND LIBRARY.

During the year 28,473 of the Bureau's publications were sent out on special requests and 10,605 were distributed by means of the regular mailing list.

In addition to reprints of 7 papers on important subjects in which there is much popular interest, the following documents descriptive of the Bureau's work or of investigations carried on in its behalf were issued during the year:

American catfishes: Habits, culture, and commercial importance. By William Converse Kendall. 38 p., 10 pl. 1910.

Report of the Commissioner of Fisheries for the fiscal year ended June 30, 1910. 40 p. 1910.

The fur-seal fisheries of Alaska in 1909. By Walter I. Lembkey. 53 p. 1910.

Marine isopods collected in the Philippines by the U. S. fisheries steamer *Albatross* in 1907–8. By Harriet Richardson. 44 p., 39 text fig. 1910.

A review of the salmonoid fishes of the Great Lakes, with notes on the whitefishes of other regions. By David Starr Jordan and Barton Warren Evermann. Bulletin, vol. XXIX, 1909, p. 1–42, pl. I–VII, 23 text fig. 1911.

Influence of the eyes, ears, and other allied sense organs on the movements of the dogfish, Mustelus canis (Mitchill). By George H. Parker. Bulletin, vol. XXIX, 1909, p. 43–57. 1910.

Barnacles of Japan and Bering Sea. By Henry A. Pilsbry. Bulletin, vol. XXIX, 1909, p. 61–84, 10 pl., 11 text fig. 1911.

The distribution of fish and fish eggs during the fiscal year 1910. 112 p. 1911.

Dredging and hydrographic records of the U. S. fisheries steamer *Albatross* during the Philippine Expedition, 1907–1910. 97 p. 1910.

The food value of sea mussels. By Irving A. Field. Bulletin, vol. XXIX, 1909, p. 87–128, 8 pl., 2 text fig. 1911.

The migration of salmon in the Columbia River. By Charles W. Greene. Bulletin, vol. XXIX, 1909, p. 131–148, 2 pl. 1911.

Anatomy and physiology of the wing-shell Atrina rigida. By Benjamin H. Grave. Bulletin, vol. XXIX, 1909, p. 411–439, 3 pl., 15 text fig. 1911.

Condition and extent of the natural oyster beds of Delaware. By H. F. Moore. 29 p., 1 chart. 1911.

The fisheries of Alaska in 1910. By Millard C. Marsh and John N. Cobb, 72 p. 1911.

Natural history of the American lobster. By Francis H. Herrick. Bulletin vol. XXIX, 1909, p. 149–408, pl. XXVII–XLVII, 42 text fig. 1911.

Development of sponges from dissociated tissue cells. By H. V. Wilson. Bulletin, vol. XXX, 1910, p. 3–30, 5 pl. 1911.

The library has been augmented to the extent of 425 titles—30 acquired by transfer, 101 by purchase, and the remainder by donation. With the increasing number of subjects under investigation, the library must of necessity grow to meet the resulting demands, and notwithstanding arrangements with the Library of Congress and other institutions in Washington for the loan of books, it is often impossible to obtain in this manner the technical works required, and considerable purchases must continue.

The extension of research work at the Woods Hole laboratory and the many lines of inquiry there undertaken necessitate a good working library, and numerous accessions were made during the year. Working libraries are also being established and augmented as rapidly as possible at the laboratories at Fairport and Beaufort.

Intimate relations are maintained with the Library of Congress, and the Bureau is indebted to it for loans and for gifts of many valuable books from among its duplicates. The library has also agreed to print author and subject catalogue cards for the Bureau,

not only for current accessions, but, as fast as data can be supplied, for those which are needed for recataloguing the entire library. When this work, thus greatly expedited, is complete, it will be possible, at small cost, to have at all the laboratories and stations a complete catalogue both of the Bureau's books of reference and its publications.

The Library of Congress donated some 400 volumes of standard and popular works from its duplicates for the benefit of the Government employees, native inhabitants, and school children on the Pribilof Islands, and many books and periodicals were obtained from private sources for the same purpose. These donations were especially acceptable, as there is no appropriation which can be used for such purposes.

CONGRESSIONAL INVESTIGATION.

On May 12, 1911, the House of Representatives adopted the following resolution:

Resolved, That the Secretary of Commerce and Labor be, and he is hereby, directed to furnish for the use and the information of the House of Representatives copies of all letters received, reports, and documents from his agents in charge of the seal islands of Alaska, together with copies of all instructions given to those officials aforesaid since January first, nineteen hundred and four, up to date, which relate to the condition and management of the fur-seal herd, the conduct of the officers of the Government in charge of it, and the conduct of the work of the lessees on the seal islands aforesaid, since January first, nineteen hundred and four, up to date.

The correspondence and other papers called for by this resolution were promptly collected, and on June 24, 1911, were transmitted by the Secretary to the Speaker of the House of Representatives. The material consisted of about 2,500 pages of manuscript, and was printed as House Document No. 93, Sixty-second Congress, first session (1,232 pages).

The resolution was based on certain charges that had been made by outside persons affecting the administration of the seal islands, and the inquiry thereunder was assigned to the Committee on Expenditures in the Department of Commerce and Labor. The first hearing was held on May 31, and the investigation was in progress at the close of the fiscal year.

APPROPRIATIONS.

The total appropriations for the fiscal year 1911 amounted to $1,003,470, as follows:

Salaries:	
General	$335,740
Alaska salmon fisheries	6,300
Alaska seal fisheries	14,430

Miscellaneous expenses:	
Administration	$12,000
Propagation of food fishes	300,000
Inquiry respecting food fishes	35,000
Statistical inquiry	7,500
Maintenance of vessels	58,000
Protecting seal fisheries	150,000
Supplies for native inhabitants, seal islands	19,500
Specials:	
Continuation of biological station, Fairport, Iowa	40,000
Continuation of fish-cultural station, Homer, Minn	25,000
Purchase of launch for Mississippi River (reappropriated)	8,000

An itemized statement of expenditures authorized by the foregoing appropriations has been made, as required by law.

RECOMMENDATIONS.

RELATIONS WITH THE STATES.

In its fish-cultural work in the various States the Bureau has no interests or purposes that are foreign to those of the States. In fact, all its operations are necessarily for the immediate benefit of the citizens of the States, and there should be the closest cooperation between the Federal and State authorities. Congress has imposed certain duties on the Bureau of Fisheries, and the fulfillment of those duties can best be achieved by the active support of the States.

Most of the States fully appreciate the necessity for cooperation and act accordingly. Some, however, are pursuing a course which results in the practical annulment of all the fish-cultural efforts of the Federal Government and of local agencies, through failure to enact and enforce legislation the nature of which and the necessity for which are often most obvious, while other States that are and long have been large recipients of the Government's bounty have enacted laws or adopted regulations that have the effect, if they do not have the object, of handicapping and of making more expensive, and therefore less extensive, the fish-cultural operations evidently contemplated by Congress and determined on by the Bureau after full consideration.

In previous years attention has been called to these matters, and the present report makes mention of some current phases of the subject. Under the circumstances that exist the Bureau has reason to feel that it is incumbent on the States, if they desire Government aid in the maintenance and improvement of their fisheries, to manifest it unmistakably by the repeal of inimical measures and by the enactment of proper legislation; to show some regard for the Bureau's recommendation in respect to laws which affect its operations; and at least to refrain from legislative and regulative acts that serve only to retard and embarrass.

The Bureau has advocated and the Secretary has been pleased to recommend to Congress that all bills for the establishment of fish hatcheries in States contain the proviso that before any final steps shall have been taken for the construction of fish-cultural stations the State, through appropriate legislative action, shall accord to the United States Commissioner of Fisheries and his duly authorized agents the right to conduct fish hatching and all operations connected therewith in any manner and at any time that may be considered by them necessary and proper, any fishery laws of the State to the contrary notwithstanding.

The Secretary has likewise accepted and has incorporated in communications to Congress the Bureau's suggestion that the operations of any hatcheries should be suspended by the Secretary of Commerce and Labor whenever, in his judgment, the laws and regulations affecting the fishes cultivated are allowed to remain so inadequate as to impair the efficiency of said hatcheries. Both of these provisions were approved by the Senate Committee on Fisheries.

In the interest of closer relations with the States in this important work it is recommended that the foregoing provisions be adhered to and that every effort be made to have them enacted into law.

FISHERY EXPERIMENT STATION AND LABORATORY.

One of the most important needs of the Bureau of Fisheries at the present time is an experiment station for the study of fish diseases and the problems of fish breeding. This recommendation was the subject of a special message from the President to the last Congress and was embodied in a bill which was passed by the Senate.

The Bureau is producing an annual output of young fish which would have, at the quotation of commercial fish culturists, a value of $1,000,000 in the hatcheries. Domesticated fish, like other domesticated animals, are subject to diseases not common to their wild state, and lack of knowledge for the prevention or cure of epidemics is the cause of serious loss to the public enterprise of fish culture. Not only this, but the most prevalent fish disease in the hatcheries is a thyroid tumor in trouts which has been shown to be of the same nature as human cancer. Although there is no evidence that cancer in fishes is communicable to man, the importance of pursuing investigation of the presumable common cause is self-evident in its humanitarian aspects. From the fish culturist's standpoint the question involves the possible necessity of abandoning certain large trout hatcheries where the prevalence of disease has made the operations unprofitable.

Of permanent importance is experimental work in fish culture similar to that conducted in plant and animal industry at agricultural experiment stations. What selective breeding has done for poultry, cattle, horses, and dogs, selective breeding may do for bass, trout, and other fishes, but this is a subject to which as yet no atten-

tion has been given owing to lack of facilities. The United States is far behind the nations of Europe in respect to this matter, notwithstanding that its fish-cultural operations are more extensive than those of all other nations combined. The experiments and investigations conducted to the small limit of the Bureau's present facilities are an indication of the possibilities and the urgent need of adequate means such as the station asked for would provide.

PREVENTION OF FURTHER DESTRUCTION OF FISH IN IRRIGATION WORK.

The heavy destruction of fish in all arid sections of the West where irrigation is a necessity is becoming alarming, and is a matter which requires serious consideration in order to secure the results which, under normal physical conditions, may reasonably be expected to follow the Bureau's efforts to maintain the fish life in streams, lakes, and reservoirs. Cooperation is eminently desirable between the Bureau of Fisheries and the Reclamation Service, in the exercise of influence to stimulate interest which will lead to the enactment of State laws compelling the screening of irrigation canals as a means of mitigating the destruction of fish life. A more effective and direct method of attaining this end, however, would be the passage by Congress of a law requiring that proper regard for the preservation of fish life be had in all irrigation work or projects to which Federal aid had been given.

EXTENSION OF FISH-CULTURAL AND OTHER OPERATIONS.

Previous recommendations for increased fish-cultural facilities are renewed, and especial attention is called to the desirability of having new stations in the Mississippi Valley, in the Southwestern States, and in the Pacific States. In addition to a fresh-water station in the last-named region, there is need for a biological station on the Pacific coast, where adequate facilities may be had for studies of the important salmon and other fishery problems, and where marine aquiculture may be taken up.

At the laboratory and hatchery at Woods Hole, Mass., a special appropriation is required for new buildings, for extensive repairs to wharves, and for general improvements.

Two new steel fish distribution cars are required to move the output of the hatcheries and to comply with modern traffic requirements, and a seagoing vessel is needed for use in connection with the marine hatchery at Boothbay Harbor, Me.

An increase in the general appropriation for propagation of food fishes is urged, and is provided for in the estimates submitted, for the proper operation of new hatcheries on Puget Sound, for repairs and improvements to prevent depreciation of station property, for increased facilities, and for the natural expansion of operations.

Owing to the approaching completion of the Fairport (Iowa) station and its operation on a large scale as a mussel hatchery and experiment station, a small addition to the present appropriation for the division of inquiry respecting food fishes is essential.

PERSONNEL.

In the estimates submitted to the Secretary for appropriations required for the operations of the Bureau for the fiscal year 1913, changes are made in the designation, compensation, and status of certain employees and provision is made for several new positions, for reasons that have been fully set forth and need not be reiterated here. Among these items that are strongly recommended are: (1) To change the title of chief clerk to assistant in charge of office and increase his compensation from $2,400 to $3,000 per annum; (2) to increase the salary of librarian from $1,200 to $1,500; (3) to establish in the division of fish culture the position of senior clerk, at $1,800 per annum, who shall act as special aid to the assistant in charge and relieve him of manifold routine duties; (4) to create in the division of inquiry respecting food fishes the position of fish pathologist, at $2,500 per annum, and to provide for one additional scientific assistant, at $2,000 per annum; (5) in the Alaska fisheries service, to increase the salaries of two physicians at the seal islands from $1,200 to $1,800 per annum and to raise the salaries of the wardens and four deputy wardens.

The deputy commissioner, the agents at Alaska salmon fisheries, and the wardens in the Alaska fisheries service are now nominated by the President and confirmed by the Senate. It is believed that these positions should be included in the classified civil service and be filled by direct appointment by the Secretary, and this recommendation is embodied in the estimates submitted.

The Commissioner takes this occasion to express to the chiefs and subordinates in all branches of the service his appreciation of their loyal support and cooperation, which have resulted in efficient and economic performance of the duties imposed by law, and he renews the recommendation of former years for a general readjustment of salaries, so that adequate compensation, commensurate with individual responsibility and capacity and with changed economic conditions, may be given throughout the service.

Respectfully,

GEO. M. BOWERS,
Commissioner.

To Hon. CHARLES NAGEL,
Secretary of Commerce and Labor.

EFFECTS OF EXPLOSIVE SOUNDS, SUCH AS THOSE PRODUCED BY MOTOR BOATS AND GUNS, UPON FISHES

By G. H. Parker, S. D.
Professor of Zoology, Harvard University

Bureau of Fisheries Document No. 752

EFFECTS OF EXPLOSIVE SOUNDS, SUCH AS THOSE PRODUCED BY MOTOR BOATS AND GUNS, UPON FISHES.

By G. H. PARKER, S. D.,
Professor of Zoology, Harvard University.

SENSE OF HEARING IN FISHES.

That sounds affect many fishes has long been recognized by fishermen and naturalists. No less an authority than Izaak Walton declared that it should be a rule with him to make as little noise as possible when he was fishing, lest he be heard and catch no fish. Nevertheless it has been only within the last few years that the sense organs concerned with the reception of sound in fishes have been definitely identified.

Using the term sound to include any vibrations of the water, from such slight movements as result from waves and currents to the vibrations that emanate from the impact of solid bodies under water or from the more violent discharge of explosives, it may be said that sounds affect fishes through three sets of sense organs—the skin, the lateral-line organs, and the ears. Within recent years it has been demonstrated that a fish can feel sounds through its skin in much the same way that a human being can feel the vibrations of a musical instrument when his hand is in contact with it. It has also been demonstrated that certain fishes sense relatively low vibrations, such as trembling movements of the water, by means of the lateral-line organs. And furthermore, though this point has been disputed, it seems clear to the writer through work carried out under the auspices of the Bureau of Fisheries that the internal ears of fishes are not only organs for the adjustment of bodily motions and equilibrium, but also organs of hearing.

THE QUESTION OF MOTOR-BOAT NOISES.

If, then, fishes are sensitive through so many channels to sounds, the question naturally arises as to the effect of the introduction of motor boats and other sound-producing mechanisms on the fishes of

our shores. Are such devices favorable, inert, or prejudicial to our fisheries, and, if prejudicial, in what ways can they be modified to make them least harmful?

Motor boats driven by exploding gasoline are equipped, as a rule, with an escape pipe which is situated close to the level of the water and through which the exploded gas is discharged in violent jets. This pipe is sometimes so arranged that its end may be dropped below the water level or kept in the air. When the gas is delivered into the air each discharge is usually accompanied by a familiar explosive noise of much penetration. When the delivery is into the water the sound is greatly muffled and freed for the most part from its objectionable penetrating character. This method of reducing the noise is so easily applied that in certain communities efforts have been made to require all motor boats to be thus muffled, at least between certain hours. The objection from the standpoint of the motor boats to this form of muffling comes from the fact that when the escape pipe is under water the obstruction to the free outward passage of the gases is so much increased that the efficiency of the motor is considerably reduced, and hence the running of the boat is impaired.

To the human ear under ordinary circumstances most motor boats either with or without mufflers are noisy appliances, generating sounds that are carried a long distance through the air. But in the water these sounds are very much less penetrating. To test this, a 7-horsepower motor boat with an exceptionally loud sound was run in open water and an observer plunged under the surface as the boat passed. When within 10 or 12 feet of the boat, whose escape pipe was in the air, the explosions of the gas could be faintly heard, though they were disagreeably loud to the observer when in the air. With the escape pipe under water and at the same distance as before the noise of the explosions could scarcely be detected at all under water. Thus both methods of running the boat delivered into the water surprisingly little sound as compared with what escaped into the air, and of the two conditions the muffled boat yielded to the water much less sound than the unmuffled boat.

In testing the effect of the motor-boat noises on fishes, a number of kinds of fish known to be sensitive to sounds, such as killifish (*Fundulus heteroclitus*), young scup (*Stenotomus chrysops*), and young kingfish (*Menticirrhus saxatilis*) were placed in a large wooden cage, 4 feet square by about 2 feet deep, whose walls were of strong netting. This cage was fastened in quiet water at the end of a float and a motor boat of 3½ horsepower and with a penetrating noise was started at a distance of some 400 feet from the cage and run at full speed past it.

An observer was stationed on the float to note any response made by the fish. Tests were made with the escape pipe out of water and with it under water, but in neither instance was there any apparent effect upon the fishes. Most of these fishes, and especially the killifish, go down into deeper water when only slightly disturbed, but in these trials they remained playing about on the surface of the water while the boat passed and were in no observable way disturbed until the swash from the boat struck the cage, whereupon they generally dove to the deeper part of the receptacle.

Another test of a like kind was carried out on mackerel (*Scomber scombrus*). About 30 of these fish that had been for one or two days in a large pocket at the end of a pound net about a quarter of a mile from shore were gathered together by having the pocket pursed up into a space about 25 feet square and 10 feet deep. In this space they swam slowly about in a circle near the top of the water.

When an observer stationed in a boat at the edge of the pocket rose in the boat the fish very usually went to the bottom of their inclosure, to return to the surface after the observer had taken his seat again. While the observer was sitting and watching the fish a second person ran a motor boat over a circular course about half a mile in circumference, the course passing close to the pocket at one point. As the motor boat passed the pocket the fish were closely scrutinized by the observer. In no instance, either with the escape pipe of the motor boat above water or under water, did the mackerel sink into the deeper part of the pocket nor did they show in any other observable way that they were disturbed by the noise from the boat. Seven of them were then isolated in the cage previously mentioned and tested under close inspection by running the motor boat past the cage, but again the mackerel gave no evidence of being disturbed by the noise.

Although these tests seem to be quite conclusive in showing that the faint noises produced in the water by a motor boat have no marked effect on the ordinary activities of certain fishes, it is not impossible that the same noises may interfere with other activities of these fishes, such as feeding, pairing, egg laying, etc. The only tests in this direction that were carried out had to do with feeding. Hungry killifish, scup, and kingfish were placed in the cage previously used and the cage was fastened to a float so that a motor boat could pass close to it. When the fish were feeding vigorously the motor boat was run by the cage several times, but in no case did the fish give up feeding in consequence of the noise.

Another test was made with baited lines. Two baited fish lines were lowered from the edge of a wharf until the bait was about 6 feet under water. In a short time the two baits were surrounded by

cunners (*Tautogolabrus adspersus*), which began to nibble actively. A motor boat was now backed up under its own power from a distance of about 50 feet till its stern was directly over the baited lines. During the approach of the motor boat the fishes continued to nibble, notwithstanding the increasing noise, till the boat was within 6 feet of the lines, whereupon the fishes ceased nibbling. On running the motor boat away for a short distance, 6 to 8 feet, vigorous nibbling recommenced. It is difficult to say whether the cessation of nibbling, which regularly occurred when the stern of the boat was brought close to the lines, was due to the noise that reached the fishes or to the churning of the water in their neighborhood by the propeller of the boat. However this may be, it is certain that cunners can be driven from bait by a motor boat only when it is very close to them and that they are apparently uninfluenced by the same boat at a distance of 10 feet or so.

If a cunner can be driven from bait by the disturbance from a motor boat close at hand, other fish may be affected in a like manner, and should these be more sensitive to noises than the cunners, it is possible that they may be influenced when boats are at greater distances than 6 to 8 feet. There is, however, very little conclusive evidence on this point. In August, about the dock at Woods Hole, young bluefish (*Pomatomus saltatrix*) are not uncommon. They are often angled for with rod and line and afford much sport for the local fishermen. They bite well, even with motor boats making much noise in the harbor and passing the dock at a distance of about a hundred feet. If, however, a motor boat comes close to the dock, they are almost certain to cease biting for a quarter of an hour or so. Observations of this kind are by no means conclusive, but they favor the opinion that some fishes are disturbed by the noises from motor boats, though these disturbances are always very temporary and local.

The noises produced by motor boats have only a slight and local influence on fishes, not only because the noises that really get into the water are very faint, but probably because they reach the fish in the most favorable way for nonstimulation. Most persons who have experimented with the effects of sound on fishes have been struck with the fact that after a fish has responded once or twice to a given sound, it often ceases to respond to further stimulation for some considerable time, and in experiments of this kind it is usual to allow relatively long intervals of time to elapse between tests in order that the fishes may return to a receptive state. In the approach of a motor boat the sound that first reaches the fish must be far too faint to call forth any response, and this sound grows so gradually in intensity and with such rapid reiteration that the fish probably acquires the state of nonreaction to sound by the time the stimulus

has grown to such an intensity as would have been effective had a single shock been delivered at once to the fish. The gradual approach of the boat, then, does away with the element of contrast between silence and loud noise, and the result is just the reverse of that of summation, so often seen in the application of minimal stimuli to sense organs; the fish fails to respond.

RESPONSE TO THE SOUND OF GUNSHOTS.

If this explanation of the general ineffectiveness of motor boats in disturbing fishes is correct, then these animals ought to be responsive at least to single, loud noises generated close to the water. As long ago as 1782 Hunter demonstrated that fishes were responsive to the discharge of a fowling piece. In his account of the internal ears of fishes he states that—

> In the year 1762, when I was in Portugal, I observed in a nobleman's garden near Lisbon a small fishpond, full of different kinds of fish. Its bottom was level with the ground and was made by forming a bank all round. There was a shrubbery close to it. Whilst I was lying on the bank, observing the fish swim about, I desired a gentleman who was with me to take a loaded gun and go behind the shrubs and fire it. The reason for going behind the shrubs was that there might not be the least reflection of light. The instant the report was made the fish appeared to be all of one mind, for they vanished instantaneously into the mud at the bottom, raising as it were a cloud of mud. In about five minutes after they began to appear, till the whole came forth again.

It is quite evident from this observation by Hunter that fishes can be disturbed by the discharge of a gun in the air, even when it is some distance from them.

To test the effect of single, loud noises on fishes several *Fundulus* were liberated in a cage, and after they had become quieted a fowling piece was discharged a few feet from them, but in such a position that they could not see it. At the report of the gun most of the fishes gave a single leap forward and to one side. This was several times repeated at considerable intervals and invariably with the same results. Bait was then thrown into the cage, and while the *Fundulus* were busy tussling with this food the gun was again discharged. They immediately forsook the bait, but in half a minute they had returned to it with full vigor. From these tests it is evident that *Fundulus* is easily disturbed by such a noise in the air as the discharge of a gun, but it is also evident that this disturbance is of a very temporary kind.

To ascertain something of the strength of the sound stimulus that caused the *Fundulus* to react an observer dove under the water, and while he was there the gun was discharged in much the same relation to him as it had been to the fishes. Although the report of the gun in the air was almost deafening, when it was heard under

a foot or so of water it resembled the pop of a soda-water bottle both in quality and in intensity. This great reduction in intensity of the sound, as in the case of the motor-boat sounds, results from the reflection of most of the sound from the surface of the water, and hence its failure to enter the water. Yet the little that did enter the water sufficed to stimulate the fishes.

Fundulus is known to be quite sensitive to sound, but the fact that it lives under water renders it relatively inaccessible to sounds, since most sounds originate in the air. This explains why *Fundulus* and most other fishes fail to respond to the human voice. It is not that the human voice in itself is not strong enough to stimulate a fish, but rather that so little sound from it enters the water that stimulation is impossible. The surface between water and air is for fishes an effective screen through which very little sound can pass.

With the view of ascertaining something of the effectiveness of a gun report as a stimulus for *Fundulus*, trials were made by firing the gun at various distances from the cage of fish. *Fundulus* invariably responded to the discharge of the gun at 100 feet from the cage; they usually responded at 200 feet; but they never responded at 500 feet. From these observations it is evident that the effect of the report of a gun is distinctly local and in this respect it resembles the motor-boat noises.

It would be a matter of great interest to ascertain what influence the firing of heavy guns has on fishes, but thus far no good opportunity for prosecuting such investigations has been found. Through the courtesy of the commanding officer of the United States revenue cutter *Gresham* it was possible to study the effect of the explosion of a saluting charge of 2 pounds of powder from a 6-pound howitzer. In these tests a considerable number of *Fundulus* were retained in a cage and the tests made at varying distances from the gun. At 2,000 feet no response was given to the report, and the same was true at 1,000 feet. Within 30 feet of the gun the conditions for accurate observation, because of the heavy detonation, were very unfavorable, but the response at this position was at most only momentary and certainly not more striking than the reaction to the report from a fowling piece.

From these observations it seems quite clear that single, loud noises generated in the air enter water to a small extent, but in sufficient volume to disturb momentarily fishes that are in the immediate vicinity. But even this limited disturbance does not seem to be produced by the ordinary motor boat which, partly because of the faintness of its sound under water and partly because of the gradual increase and decrease of the sound in intensity as the boat approaches and recedes, is relatively inert so far as many fish are concerned.

CERTAIN SOUNDS ATTRACTIVE TO FISHES.

The problem of the relation of fishes to sounds is almost always taken up from the standpoint of negative reaction, in that it is assumed that noise drives fishes away. It must be remembered, however, that there are fishes, like the drumfish and especially the squeteague, that produce noises which are without much doubt concerned with bringing the sexes together in the breeding season and that these noises, therefore, are not repellent but serve to attract. Cases of this kind show that it is possible that even artificial noises, if appropriate in character, might attract fishes, for sound, even when disagreeable to the human ear, is not of necessity always disturbing to fishes and might even serve as a lure.

CONCLUSIONS.

The sounds produced by motor boats are extremely faint under water and have little influence on the movements and feeding of fishes. Such influence as they do have is temporary and very much restricted in local extent.

Single explosive sounds, like the report of a gun, may startle fish and cause them to cease feeding, but these responses are also temporary and local.

Although most sounds are repellent to fish, some may serve as lures to particular species.

THE MUSSEL FAUNA OF THE MAUMEE RIVER

By H. Walton Clark and Charles B. Wilson

Bureau of Fisheries Document No. 757

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THE MUSSEL FAUNA OF THE MAUMEE RIVER.

By Charles B. Wilson and H. Walton Clark.

INTRODUCTION.

This report embodies the results of an investigation of the mussel fauna of the Maumee River, carried on under the auspices of the United States Bureau of Fisheries during the summer of 1908, and it represents a part of the series of investigations undertaken by that Bureau looking toward means of continuing the supply of mussel shells. Upon this supply, which had begun to show signs of serious depletion, depends one of the important industries of the country, the pearl-button industry of the Mississippi Valley.

The scope of the inquiry embraced whatever appeared to be closely related to mussel life, such as the history and character of the river and its present mussel supply as regards abundance, quality, and species. It was desirable also to ascertain where good breeding stock might be obtained, the location, character, and condition of mussel beds, and circumstances in which different species appeared to thrive. Such features of general life history as food, habits, time and manner of spawning, enemies, and parasites were also noted whenever opportunity offered.

In the choice of the area to be studied, the features to be emphasized during the investigation, and similar details we have had the direction and advice of Dr. Barton W. Evermann, Chief of the Division of Scientific Inquiry of the Bureau of Fisheries. His counsel has been of great assistance in the preparation of this report.

In addition to the Maumee River, the upper part of the Wabash Basin was also investigated, in order that the two basins might be compared where they are close together. This latter part of the work also yielded many interesting results, especially in the spawning habits of mussels and the life history of parasites. The results of the Wabash investigation are frequently referred to briefly where they carry on lines left incomplete by the Maumee studies.

The authors had as an associate in the work Mr. Donald M. Earll, of Washington, D. C., to whom is due much credit for the results.

During the Maumee investigations, not only the main river, but also the two streams which unite to form it, the St. Joseph and St. Marys, were examined for the last few miles of their course, and the other principal affluents, the Tiffin and the Auglaize, were likewise investigated for a short distance above where they join the Maumee. Other bodies of water flowing into the Maumee or closely related to its basin, such as the feeder canal at Fort Wayne and its reservoir, and Spy Run, a small tributary to the St. Marys not far above its mouth, were studied. Below Defiance, Ohio, the Miami and Erie Canal runs parallel with the river, and was followed to avoid the riffles and difficulties of navigation to be encountered in the main stream. It offered a favorable subject of research in itself and the Maumee could readily be examined from time to time, as that river was never any great distance away.

During the trip to the United States fish hatchery at Put-in Bay, Ohio, opportunity was taken to examine the mussel fauna of that region. This gave data for inference as to which species had probably ascended the Maumee from Lake Erie and which had entered more recently from the Wabash system. It also furnished a basis for comparison between the river and the lake mussels as regards size, etc.

The authors are about equally responsible for the work. To Mr. Clark belongs the credit for the final determination of the mussel species, all of the observations on the food of mussels, and most of those upon the parasites. Dr. Wilson supervised the work and has furnished the geological and geographical distribution and most of the notes upon the various stations.

GEOLOGY AND GEOGRAPHY OF THE MAUMEE AND UPPER WABASH BASINS.

Although the Maumee River flows into Lake Erie and is therefore a part of the great St. Lawrence system, while the Wabash flows into the Ohio and thence to the Mississippi, the basins of the two rivers have been so intimately connected in their geological history and topographical features, as well as by the artificial connections established during the existence of the Wabash and Erie Canal, that they are practically one. Even at the present day the headwaters of the Little Wabash River approach within 3 miles of the St. Marys River and still nearer to small affluents of that stream, and when the white settlers first came to Fort Wayne they found this point an important portage for the native Indian tribes. There is no perceptible divide between the two basins, and a large open country ditch still unites them through an old flat lake plain known locally

as "the prairie." A careful examination of this ditch revealed no mussels at all, and it is not likely they could live in the mucky bottom, though it is possible that glochidia might be carried through the stream by migrating fishes.

During the glacial period the entire region was buried under the ice, and every form of molluscan life was exterminated. At the melting of the ice sheet great bodies of water were formed which could find no outlet to the eastward on account of the still unmelted ice, and therefore all the water was compelled to drain toward the south and west into the Ohio and Mississippi Valleys. The old channels can still be traced and are represented on the geological maps of the region. The geologists tell us that at first there were two of these lakes entirely separated from each other. The easternmost one, Lake Maumee, covered the present basin of the Maumee River and the upper part of the Wabash Basin and was 100 feet higher than Lake Chicago, which lay to the west. Lake Maumee drained through the Maumee and Wabash Valleys into the Ohio, while Lake Chicago found an outlet along the Des Plaines and Illinois River Valleys.

The restocking of the region with mussels must have been effected by migration through these respective outlets. At this period several of the more hardy species came up through the Wabash Basin into Lake Maumee, as is attested by the finding of their shells among the fossils of the period. At the beginning, therefore, the Maumee Basin was restocked with Ohio Valley species of mussels, which came to it by way of the Wabash River.[a]

After the ice had retreated far enough northward to reveal the surface features of the region under discussion, it exposed the valley of an ancient preglacial river, sometimes called the Huronian River, and now known as the Saginaw-Grand Valley. This river valley runs east and west across the southern part of the State of Michigan and became a channel connecting the two lakes just mentioned. The opening of this channel gradually lowered the water in Lake Maumee to the level of that in Lake Chicago. A series of terminal moraines which had formed along the southern margin of Lake Maumee were enabled by this lowering of the water to assert themselves and close the Wabash outlet. These moraines are known to geologists as the Mississinewa Moraine, to the south and west of which lies the Mississinewa River, the Salamonie Moraine, to the north and east of the Salamonie River, the Wabash Moraine to the north and east of the main branch of the Wabash River, the St. Joseph-St. Marys Moraine to the east of those two rivers, both of which drained originally into the Wabash, and the Defiance Moraine

[a] For an interesting discussion of this subject, see Simpson, American Naturalist, vol. xxx, p. 379–384.

to the east of the Tiffin and Auglaize Rivers. The former drainage of the St. Joseph and St. Marys Rivers through the Wabash is indicated by the peculiar turn they make at Fort Wayne, where they unite to form the Maumee. This sudden change, of course, is so striking a feature that it has excited comment by almost everyone who has considered the topography of the region. The situation is well expressed by Mr. Simpson who says:

> The St. Josephs, St. Marys, and Auglaize Rivers, tributaries of the Maumee, flow in the direction of the Wabash; the two former join at Fort Wayne and flow partly backward as the Maumee, the whole looking like a tree with its branches broken down and hanging against its trunk.[a]

From the time of the closing up of the Wabash outlet until the St. Lawrence was reopened, the only outlet for Lake Maumee was through the Huronian channel into Lake Chicago, and thence into the Des Plaines and Illinois Rivers. All the mussels, therefore, which took part in restocking Lake Maumee during this period belonged to the Illinois River fauna and entered the lake by this roundabout channel. The Unionidæ are essentially inhabitants of shallow water and would have spread along the margin of these glacial lakes. As the level of the lakes was gradually lowered and the present system of drainage was established, the mussels naturally followed the retreating waters, and thus finally found their way into the river beds where they now live.

This account of the origin of the present mussel fauna in the Maumee and upper Wabash Basins is adapted from several geological reports of the States of Indiana and Michigan and from an excellent paper on the "Distribution of the Unionidæ in Michigan" by Bryant Walker.[b]

From the foregoing account of the manner in which the stocking of the Maumee Basin took place, it would naturally be inferred that in the lists of species of mussels obtained at the various stations on the Maumee and Wabash Rivers by the party, there should be more than the usual amount of similarity between those from the headwaters of the two rivers, and this similarity should decrease the farther down the respective rivers the comparison is made. Such we find to be actually the case. (See p. 38.)

But there is another factor which may at least claim a share of the credit for the correspondence in species.

The Wabash and Erie Canal was in active operation between these two rivers for nearly half of the last century. Starting at Toledo, Ohio, it ran along the bank of the Maumee for the entire length of that river to Fort Wayne. There it crossed the narrow strip of country between the headwaters of the two rivers, ran along

[a] American Naturalist, loc. cit.

[b] Author's separate of a paper read before the Michigan Academy of Science, March, 1899.

the edge of the old lake plain or "prairie," near the Indian portage and at no great distance from the Little Wabash, struck the main Wabash below Huntington, Ind., and then followed the latter river down to the Ohio. This canal was fed from the two rivers and opened into them at various points along its course.

There was thus established a channel of communication which, during its half century of existence, must have resulted in the exchange of many species of mussels, as well as other portions of the fauna of the two rivers.

Such a canal furnishes an excellent breeding ground for mussels, as is well shown in the case of the old feeder canal at Fort Wayne (p. 19) and the Miami and Erie Canal still in existence between Defiance and Toledo (p. 34).

This artificial opportunity for interchange of species, occurring so recently, must have greatly supplemented the original similarity due to the former identity of the drainage basins. It would also go far toward destroying any local peculiarities that might have developed since the two basins were separated.

The Maumee Basin is situated in the northeastern part of Indiana and the northwestern part of Ohio, and covers an area of 6,500 square miles. There are no large hills in or around it, it being a flat glacial plain, covered with moraines and low ridges. The basin abounds in clay and solid subsoil, so that the river is rather muddy most of the time. The water is also quite hard, furnishing an abundance of lime to the mussels for their shells. In the upper part of the river, as far down as Defiance, Ohio, there is considerable sand and gravel bottom, but below Defiance a good deal of the bottom is solid bedrock. As already stated, the Maumee is a very young river in point of geological time, yet, next to the Detroit River, it is the largest tributary of Lake Erie and is one of the largest rivers within the State of Ohio. The Maumee is formed by the junction of the St. Joseph and St. Marys Rivers, just beneath the Columbia Street Bridge in Fort Wayne, and flows northeast to Lake Erie at Toledo, Ohio. From origin to mouth is about 100 miles in a straight line, but as a result of the angular or crescentic form of the glacial moraines which separate the Maumee from the Wabash Basin, the river winds greatly, especially that portion of it above Defiance, and thus adds fully 50 miles to its length.

As might be expected, the current is not very swift except during high floods, since the river falls but 164 feet in its entire course, or a trifle over a foot a mile, and much of this is accumulated in a series of riffles at Defiance and Grand Rapids. Elsewhere the river is made up of long, sluggish stretches, alternating with short riffles of varying lengths, and it is in the vicinity of the latter that most of the mussels are found.

Through the removal of most of the forests which once covered the area about its headwaters, the current and depth of water are not so constant as they once were, but the river rises and falls more suddenly, and is usually considerably more turbid or muddy than formerly. The height and activity of the river in times of flood are strikingly manifested by the tangled piles of drifted logs and brush up on the flood plain high above the normal surface of the river.

This change in the steadiness of flow of the river, with the accompaniment of a more shifting bottom, has probably had considerable effect on the mussel life of the stream.

BIOLOGY OF THE MAUMEE RIVER.

Through the abandonment of the Wabash and Erie Canal, which took place nearly 30 years ago, and the draining and gradual drying up of the old lake plain or prairie, the Maumee River has become isolated from the Wabash, so that there has been no transference of species for some time.

In the course of our work our attention was devoted chiefly to the mussel fauna. The general features of the river and its inhabitants, both plant and animal, undoubtedly have many important relations to the mussels, but, on account of the limited amount of time at our disposal and the impracticability of carrying on several lines of work at once, only such features were noted as appeared to have some evident bearing on mussel life. In the St. Marys River and about the region of Fort Wayne, where conditions were favorable, the river was more thoroughly explored than elsewhere, the flora and fauna were noted, and the stomach contents and parasites of the mussels were examined. All along the way stomach contents and parasites were preserved for future study.

A valuable addition to our knowledge of the biology of the Maumee Basin has been furnished by a report of the investigations made by Philip H. Kirsch during the summer of 1893 and published in the Bulletin of the United States Fish Commission (vol. XIV, for 1894). This report refers to an abundance of algæ in various places, and furnishes a list of 87 species of fishes, 3 species of mussels in the Maumee, 4 species of crawfishes, 7 of batrachians, 6 of snakes, and 6 of turtles. In this report the remark is made that mussels are common.[a] They are, however, only incidentally mentioned, so that

[a] The mussels obtained by Kirsch during these investigations were later turned over to Mr. C. T. Simpson for examination. In an interesting discussion concerning the "Mississippi Valley Unionidæ found in the St. Lawrence and Atlantic drainage areas," in the American Naturalst, vol. XXX, p. 379–384, Mr. Simpson remarks of these shells:

"This changing of characters" [a number of changes have just been discussed] "has been well illustrated in a lot of Unionidæ recently submitted for examination by Prof. B. W. Evermann, of the U. S. Fish Commission. * * * *Unio luteolus* Lam., *U. subrostratus* Say, *U. circulus* Lea, *U. phaseolus* Hild., *U. multiplicatus* Lea, *U. multiradiatus* Lea, and *Anodonta grandis* Say, are so dwarfed and stunted and changed in color as to be scarcely recognizable, while the same species from the Wabash from which these have no doubt all been derived, are as vigorous and finely developed as any in the Mississippi Valley."

Kirsch's report and the present one may be regarded as supplementary to each other.

The following general observations were made concerning the biology of the stream:

Among the aquatic plants, *Oscillatoria* was abundant in the St. Marys River and the upper portion of the Maumee down as far as Kern Reservation, 7 miles below Fort Wayne. In the St. Marys this plant was found floating in large blackish or blue-green bunches on the surface of the river;[a] farther down much of the floating *Oscillatoria* seemed recently washed in. Filamentous algæ, probably *Cladophora*, grew on the rocks in the bottom and occasionally on the shells of the mussels. Wild celery (*Vallisneria spiralis*) was abundant on the bottom of the St. Marys at Fort Wayne, but was not conspicuous farther down. The dense-flowered water willow (*Dianthera americana*) fringed the edges of the river and lower portions of the canal all along the way and was one of the plants most constantly seen. During the latter part of the cruise along the Miami and Erie Canal this plant was covered with large tangled clumps of dodder, so that the prospect either way along the canal was lined with great masses of yellow here and there. Algæ of many sorts grew in great abundance in the Maumee below the dam at Defiance. Portions of the canal from Napoleon, Ohio, to the locks below were covered with a dense scum of delicate little water fern, *Azolla caroliniana*. Along the lower stretches of the canal *Ceratophyllum* was abundant in stretches of quiet water. *Typha latifolia*, the narrow-leaved cat-tail, formed a dense hedgelike growth along the edge of the canal in places. The spatterdock, *Nymphæa advena*, was fairly common along the lower reaches of the canal and the white water lily, *Castalia odorata*, occasional. Duckweeds were common in the canal, but not noted in the river.

As to animal life, various species of protozoa were very abundant in one place in the St. Marys, as will be described later on. (See p. 13.) They were not noted farther down the river; however, there was little opportunity to examine carefully for them. No plankton was taken, but the material examined from the stomachs of mussels probably gives a fair notion of the nature of the smaller free plankton elements. Sponges and flatworms were rather common on rocks and shells the whole length of the river. In addition to the mussels, various mollusks such as *Pleurocera*, *Ancylus*, and *Sphærium* were common. Crawfishes were abundant everywhere in the river, but were not often noted in the canals. Aquatic insects and larvæ were not

[a] Further observations show that the presence of *Oscillatoria* and other minute organisms is a periodic phenomenon. They accumulate during periods of low, stagnant water but altogether disappear during periods of high water with rapid current.

especially abundant, except below the dam at Defiance. According to residents of the region along the river, fishing was in general rather poor, although in a few places, as several miles above Defiance and below Defiance Dam, angling was enthusiastically carried on by men wading out in the stream in high boots and casting. In the autumn of 1907 a good deal of angling was observed in the St. Joseph River just above its mouth, at Fort Wayne. The anglers there were catching a good number of the wall-eyed pike, or pike perch, *Stizostedion vitreum*, which they called "pickerel." We did not see many fishes in the water during most of the cruise, although at Fort Wayne, where we had opportunity to examine carefully, a number of species were observed, and all along the Maumee the small-mouthed black bass seemed fairly common. The darting fishes frequently struck the boat with resounding whacks and occasionally jumped over the boat or even over our heads as we sat in the boat. They frequently jumped against different members of the party and fell back into the water, and 6 examples, most of them quite large and fine, jumped into the boat and were captured. At one place, a little above Woodburn, Ind., we passed through a large school of basking gars.

Among aquatic birds and waders, kingfishers (*Ceryle alcyon*) were fairly common, green herons (*Ardea virescens*) and the great blue heron (*Ardea herodias*) were quite abundant, the former along shore or on branches of trees and the latter standing statuesquely on rocks in midstream and rising with a low level flight as we approached. We saw several small flocks of wood ducks (*Aix sponsa*) which seem to be summer residents. Sandpipers were common along shore and flocks of killdeer occasional on bars. On account of the northern latitude it is perhaps worthy of note that the song of the Carolina wren came to us frequently from the woodlands along the upper stretches of the river.

No aquatic mammals were seen, although occasional shell piles gave evidence of the presence of a few muskrats.

MUSSEL SURVEY.

HEADWATERS OF MAUMEE AND LITTLE WABASH BASINS.

The region in and around Fort Wayne is of peculiar interest, since it is the borderland between the two river basins, and also furnishes much evidence of the influence of the old Wabash and Erie Canal upon the mussel fauna. For this reason, considerable time was spent here before beginning the specific work upon the basins themselves. Most of the localities reported upon were worked over several times

in order that there might be a reasonable certainty that all the resident species had been found. A careful study was made of the species themselves and data collected as regards food, parasites, etc. The localities examined include the St. Marys and St. Joseph Rivers, Spy Run, a small tributary of St. Marys, and an old feeder canal and its reservoir which was formerly connected with the St. Joseph River.

The Aboit and Little Wabash Rivers, which belong to the Wabash system, were also examined. The stations at these localities are designated by letters, those on the main river by numbers. The relative abundance of the different species at each station is indicated by giving the number of examples obtained, or by remarks.

ST. MARYS RIVER AND SPY RUN.

In the St. Marys River the shells are scattered irregularly everywhere, so that along the bank a few dead shells may be found every now and then, or an occasional live mussel seen in the water. There are a few shell beds, all of small size, however, where conditions appear to have been exceptionally favorable for the development of molluscan life, and at such places the mussels are fairly abundant.

Station A. Above the Bluffton Road Bridge, at Fort Wayne.—The highest point at which the St. Marys River was examined was above the Bluffton Road Bridge, about 4 miles from the mouth of the river. At this place there were riffles and the remains of an old dam, and the point lies above the entrance of most of the sewage of the city. The water was shallow and the bottom covered with gravel, sand, or mud, according to the rapidity of the current. At the date examined (June 26) the water was quite turbid and nothing could be seen on the bottom. We had heard reports of a goodly number of shells there, but by wading about considerably we found only a few. The living mussels were hard to find, partly because of the stony bottom and partly because of their actual scarcity. A man fishing at the place was offering boys who were swimming near by 5 cents apiece for mussels, which he wished to use for bait, and it was noteworthy that although the boys were searching diligently the fisherman was not oversupplied. We found a fair number of dead shells on the shore, representing 18 species.

The little *Truncilla sulcata*, which seemed on the whole a rather rare shell, and of which during the entire summer's work we found only 1 live example (although scattered valves were occasionally found along the river bank), seemed unusually common here; we obtained 4 entire shells and 10 valves. None of the larger species of mussels were present in sufficient numbers to be of commercial value,

while all of the others were either too small or so discolored as to be unfit for use.

The river was followed from this point down to Swinney Park, a distance of about a mile and a half, but practically no shells were seen, and men wading in the river fishing for crawfishes with dip nets knew of none. From Swinney Park down to the riffles, soon to be discussed, the river had been examined fairly well during the previous year, and no shell beds of any importance had been found. Occasionally dead shells had been seen scattered along shore and in one place a few large *Lampsilis ligamentinus*, which had probably been killed by fishermen for bait.

Station B. Riffles, St. Marys River below the Van Buren Street Bridge.—The most important bed found in the St. Marys River was at the riffles, about an eighth of a mile below the Van Buren Street Bridge and across from the city waterworks pumping station.

The riffles are conveniently near the residence of Miss Elizabeth J. Bowman, at 719 Michael Avenue, who very kindly gave us the use of her house and grounds as a laboratory headquarters for the work in and around Fort Wayne. Being so favorably situated, this station was repeatedly visited and the mussels obtained were carefully examined for food, parasites forming pearls, etc.

As the opportunity for doing laboratory work is rather rare in moving field parties, and as it was supposed that this mussel bed would be fairly typical of others we would encounter but would not have opportunity to study fully, this bed was investigated and the observations noted in considerable detail.

The stretch of river above the mussel bed was about 8 feet deep at its greatest depth and 60 or 80 feet wide, with a sandy bottom, and was used by the boys as a swimming-hole. A large quantity of sand for building purposes had been hauled out of the river at this place and screened some little distance from the river bank. Among the screenings was a fair number of mussel shells of different species and shells of *Pleurocera* and *Sphærium*. The species of mussels represented by the shells among the screenings were *Quadrula rubiginosa*, *Q. undulata*, *Pleurobema clava*, *Unio gibbosus*, *Symphynota complanata*, *Anodonta grandis*, *Lampsilis gracilis*, *L. rectus*, *L. ligamentinus*, and *L. luteolus*. There were not many live mussels to be found in this stretch of the river, probably on account of disturbances caused by the hauling of sand.

There were also few found below the riffles, as the stones were too thick in the river bed to furnish any foothold. The shell bed itself was therefore on a slope between the shallower portion of the riffle and the deeper sandy bottom upstream. The bottom on which the

mussels were located was composed of mingled sand and pebbles. The water over the mussel bed was shallow, averaging about 2 feet in depth during the period of observation, and the current was moderate, 3 or 3½ miles per hour. The water varies considerably in depth and turbidity at different times; even a small local shower raises the surface perceptibly and makes the water very muddy, after which it slowly abates in volume and becomes clear. While this mussel bed was under observation it was occasionally rendered unworkable for a few days by local showers. On the other hand, the water was sometimes found clear enough to see the bottom with a fair amount of distinctness.

The life conditions of the riffles and the swimming hole just above it were studied in considerable detail. The river flora did not appear to be particularly rich. The only conspicuous alga was a species of *Oscillatoria*, which was very abundant on the surface in large floating blue-black patches from which the filaments radiated in every direction. Of phanerogams, the only aquatic plants growing in the river at this place were eelgrass or wild celery (*Vallisneria spiralis*) and the dense-flowered water willow (*Dianthera americana*).

The animal life was rich and rather varied. One of the most abundant animals was a *Vorticella*-like protozoan, probably *Epistylis*, which thickly covered with a uniform hoary coating the blades of *Vallisneria* and the branches and leaves of willow which dipped into the water. The same or a similar protozoan grew in great abundance on the crawfishes of all sizes, especially thickly on the antennæ, which were rendered quite white and plumose. Examples of the protozoan taken from the crawfishes showed the zooids thickly clustered at the apex of a long nonretractile dichotomously branching stem. On account of the nonretractility of the stem, this white coating can not contract into a mass when irritated as can colonies of *Vorticella*. A small colony of *Vorticella* was found clustered on an *Atax* taken out of a mussel. A species of fresh-water sponge was very common below the shell bed, frequently coating the inside of dead valves with an expanded thick feltlike covering. The brown hydra (*Hydra fusca*) was quite abundant, and numerous examples were seen attached to the back of shells of *Ancylus*. Leeches did not seem to be abundant; the only one noted was a fish leech attached to a sunfish caught in the river.

In addition to the mussels, discussion of which will be reserved till the end of the description of the locality, various univalves such as *Pleurocera*, *Physa*, and *Ancylus* were common.

The crawfishes were so abundant at this place as to deserve special mention. So far as examined the species was *Cambarus virilis*

Hagen, and the river bottom appeared to be almost overpopulated with them. The young were often seen crowding up close to the shore. As noticed above, many were thickly covered with a growth of protozoa, and some of the young were covered with a green algal growth. In the mussel bed the crawfishes were seen sunning themselves on the rocks which projected out of the water, lifting themselves high upon the pincers in a most peculiar fashion. Upon wading out to a large projecting rock situated in the river about in the middle of the mussel bed they were found to be clustered thickly on the sloping surface of the rock just at the water line, their heads projecting out of the water. Many were found living in dead mussel shells just below the bed; indeed, it was hardly possible to pick an old shell or tin can out of the water without obtaining a crawfish. Some of those thus captured were of very large size. The crawfishes were frequently observed devouring the flesh of dead mussels, but it is doubtful whether they were able to kill any, especially the larger ones. They may possibly be an intermediate host of some of the mussel parasites. The crawfishes were caught in considerable numbers, either by dip nets or minnow seines, for fish bait and were used in the St. Joseph River. On July 2 a man was observed seining crawfishes just below the mussel bed at the riffles. The seine was drawn over the bottom, which was covered with rounded pebbles about the size of hen's eggs or larger, and the ends of the brails poked about among the rocks. The crawfishes, of which it seemed there was one under nearly every stone, backed up into the net and were caught in great numbers. The fisherman wanted only the soft-shells and "peelers" (crawfishes about to molt) and threw the rest back. A great number were molting at the time. The "peelers" can be easily distinguished from other crawfishes by pressing the sides of the carapace, which arches up free from the body. They also have a somewhat different color. The molted carapaces of crawfishes and gastroliths associated with them were quite common along the shore of the river.

No crustaceans except crawfishes were noted in the river itself, though small Entomostraca were abundant at the edge of the river, in overflow pools.

Aquatic insects and larvæ did not appear to be particularly abundant so far as species were concerned; a few forms, however, were quite common. The red "blood worm" (a *Chironomus* larva) was present in large numbers, and along shore, just under the water surface and attached to submerged objects by a short slender pedicel, was a great number of small gelatinous pear-shaped objects full of minute dots, probably egg bunches of *Chironomus*. Midges were abundant, emerging in great numbers; on the morning of June 21

there were many exuviæ on the water surface and on objects along shore. Many of the insects died shortly after emerging.

On the first visit to the swimming-hole, the afternoon of June 14, a large number of johnny darters (*Boleosoma nigrum*) and a few minnows were observed dead along shore. All the fishes were quite small, apparently the young of the year. It is very likely that some sudden pollution of the river about that time was the cause of the death of the fishes as well as that of a great number of large crawfishes on shore and mussels in the water. Some time during the summer it was reported that dyestuff had been poured from the knitting mills some distance above into the river and had caused a wholesale destruction of fishes, which died in such numbers as to render portions of the city along the river scarcely habitable. In addition to the dead fishes mentioned above, the following species were observed: Catfishes (young, probably *Ameiurus natalis*), mad toms (*Schilbeodes gyrinus*), golden shiners (*Abramis crysoleucas*), carp (*Cyprinus carpio*), and sunfishes (*Eupomotis gibbosus*). In the previous year a number of small black suckers (*Catostomus nigricans*) were seen at this place.

Of reptiles, a few painted turtles (*Chrysemis marginata*) were found. There were no indications of aquatic mammals, such as tracks or piles of shells along the shore. Late in autumn, however, a good many crawfishes were seen along shore with backs bitten open, and this may have been done by a muskrat or a mink.

As has been said, although a few mussels could be found above the main bed, the greater number were to be obtained just at the head of the riffles in a fairly compact bed. The mussel bed itself is quite small, probably not more than 2,000 square feet in extent, and commercial operations would clean it out in a very short time. On several occasions the water was clear enough to see the bottom and the distribution of the mussels fairly well. The mussels did not appear to be moving. They were headed mostly downstream, the natural position for feeding mussels, and were not deeply buried; about half of the shell projected out of the mud. The projecting portion was more or less stained and frequently covered with an algal growth.

On June 20 this bed was gone over with considerable thoroughness and a number of mussels collected. These were placed on shore, counted, and sorted over, and, after a number of representative shells such as were desired for specimens were picked out, the rest were thrown back. All the shells, especially *L. rectus* and *L. ligamentinus*, were large and fine. A number of the living animals were measured and weighed, with the results shown on the next page.

MEASUREMENTS AND WEIGHTS OF ST. MARYS RIVER MUSSELS.

Serial No.	Species.	Length.	Height.	Thickness.	Weight.
		mm.	*mm.*	*mm.*	*Ounces.*
1	Quadrula undulata	115	85	48	10.75
2	.....do	104	77	45	8.25
3	.....do	102	82	44	8.50
4	.....do	86	67	35	4.75
5	.....do	80	60	35	3.75
6	.....do	76	60	31	3.50
7	.....do	72	57	30	3.00
8	Lampsilis rectus	158	70	50	13.75
9	.....do	159	67	47	14.50
10	.....do	134	60	40	7.75
11	.....do	150	66	47	13.75
12	.....do	153	74	48	12.75
13	.....do	141	66	42	12.50
14	.....do	154	68	50	8.75
15	Lampsilis ventricosus	126	90	54	13.75
16	.....do	110	80	45	8.25
17	.....do	83	67	40	4.75
18	Lampsilis ligamentinus	137	83	53	16.50
19	.....do	135	84	55	15.50
20	.....do	145	88	58	18.25
21	.....do	135	83	55	15.75
22	.....do	131	82	58	14.75
23	.....do	132	80	49	13.75
24	.....do	130	80	49	11.75
25	.....do	126	79	51	12.00
26	.....do	131	79	52	12.75
27	.....do	122	79	48	12.25
28	.....do	115	79	48	10.75
29	.....do	97	63	40	5.25
30	.....do	120	75	55	11.75
31	.....do	122	80	45	10.00
32	Lampsilis luteolus	124	70	46	9.25
33	.....do	127	73	52	10.75
34	.....do	134	71	49	11.00
35	.....do	127	74	56	11.75
36	.....do	126	76	50	10.75
37	.....do	118	69	51	9.25
38	.....do	102	60	48	6.50
39	.....do	92	60	37	4.00
40	Symphynota costata	123	68	36	6.75
41	.....do	95	56	28	3.25
42	.....do	111	65	31	4.75
43	.....do	113	66	38	5.75
44	.....do	95	55	27	3.00
45	.....do	111	60	33	5.25
46	.....do	101	55	29	3.50

Below the mussel bed and also in it were a large number of dead shells. These were covered with water and appeared to be still as good for commercial purposes as ever, since they retained their original texture and luster. Some of the shells that had been longest dead were stained black, perhaps from iron in the water, but this color was superficial and could have been easily ground off. The mussels appeared at the time of our visit to be dying in some numbers, for a good many still retained the position they had during life and the flesh was still clinging to the interior of the shell. Some of the larger living shells were diseased and stained brown or green in the neighborhood of the cardinal teeth.

The stomachs usually contained considerable mud, in which was scattered a few diatoms, *Scenedesmus*, *Phacus*, etc.; the amount of organic material was quite small. The results of studies of stomach

contents are given in detail under the general heading at the close of this report. (See p. 57.)

When examined in June these mussels were strikingly barren. The only gravid individual noted was an example of *Lampsilis ventricosus* with the shell of a marked female contour very much inflated, and this was partly barren, the gills appearing shrunken. Subsequent investigations showed that the sterility of this bed was due partly to the season. As we went downstream and the season advanced we noticed gills of various species beginning to take on a dusky tinge at the margin and filling up with fertilized eggs and glochidia. Moreover, on a visit to this mussel bed on September 21, of 28 examples of *L. ligamentinus* procured 8 were gravid. The other species procured in September were: *Quadrula tuberculata*, 1; *Q. rubiginosa*, 1; *Q. undulata*, 3; *Symphynota complanata*, 1; *Lampsilis rectus*, 3; *L. luteolus*, 2; none gravid. The percentage of breeding mussels was hardly as great as one might expect under favorable conditions. No small shells were found, the smallest being of medium size and apparently several years old. The conditions on the whole seem to indicate that this mussel bed is dying out. It would have been possible to secure a number, perhaps a half ton, of good shells here without disturbing the mussels.

The riffles were incidentally visited in November, and although the water was quite cold the protozoa were still abundant on crawfishes and dead leaves in the water, and the conditions bore considerable resemblance to those observed earlier in the year.[a]

None of the mussels was badly parasitized.[b] *Atax ypsilophorus*, *Aspidogaster conchicola*, and *Cotylaspis insignis* were rather common, but not abundant. The marginal cyst distomid was rather frequent, and it was here we obtained material with which we were able to associate this organism with pearl formation. It was most common in *Lampsilis ligamentinus*.

From the riffles down to the mouth of the river mussels appeared to be quite scarce.

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[a] On June 26, 1909, as opportunity permitted, this place was revisited. It was during a long period of high water. The river, though turbid, was not filthy and appeared reasonably clean. At the riffles it was racing at a rapid rate and the current could hardly be stemmed when about breast-high, but would sweep one off his feet. No Protozoa were seen, and only a few young crawfishes, which were very active and alert. A few gray-back minnows were swimming about on the surface, and schools of small minnows darted from shore. By wading about a great deal only two live mussels (*L. ligamentinus*) were found, though there were a number of dead shells. There were no evidences of unhealthy conditions or overcrowding; on the contrary, the conditions seemed to be those of an ideal mussel stream. This visit served to emphasize the fact that during periods of high water sewage is comparatively innocuous and that while the water of the river has great variation the river population is fairly constant; in periods of low water the stream is overpopulated and, to use a chemical phrase, the inhabitants are almost precipitated out.

[b] The parasites are more fully discussed and described at the end of the report.

Station C. Spy Run.—Spy Run is the name of a small shallow stream which enters the St. Mary's about a half mile above its mouth. The bottom is of fine sand and the water at the time visited was quite clear. There were many small fishes, chiefly the johnny darter (*Boleosoma nigrum*), a few golden shiners (*Abramis crysoleucas*) and chubs (*Semotilus atromaculatus*), and a number of crawfishes, all free from Protozoa. No living mussels were found, but about a dozen dead shells, all of which, except fragments of one *Lampsilis iris*, were *Anodontoides ferussacianus subcylindraceus*.

ST. JOSEPH RIVER AND FEEDER CANAL.

The St. Joseph River, more commonly known by the shortened local name St. Joe, is a larger and clearer stream than the St. Marys, and since only the very lowest portion of its course enters the city, it is much freer from sewage.

Station D. St. Joseph River at Robinson Park, 6 miles north of Fort Wayne.—The highest point at which the St. Joseph River was examined was at Robinson Park, a pleasure resort about 6 miles above the city. This point could easily be reached by trolley. Considerable change had taken place in the river here within the last few years. At the time the park was established there was a dam in the river which had kept the feeder canal, just above, full of water. This had raised the water of the river and had expanded it somewhat into a quiet, pondlike basin. The breaking of the dam had reduced the water to its normal height and emptied the canal.

At the time of our visit the river was rather high and turbid from recent rains. We procured a boat and rake at the park and rowed up to the riffles about half a mile above the park, examining the river and shore.

There was a fair number of shells scattered along here, all of which were large and of excellent luster. The large shells found at the park itself had been dead some time, and may have been killed by the lowering of the water when the dam broke; the *Lampsilis luteolus* were exceptionally large and fine. Farther up the stream large dead shells were collected on the bank, chiefly *Quadrula undulata*. They were freshly dead and had probably been killed for bait. On investigating the river it was found full of snags in some places; in others the bottom was of hard clay, too compact for mussels to live in. In the beds of gravel where mussels were likely to be found the bottom was full of sharp rocks which in the turbid water were difficult to distinguish from mussels, so that collecting the latter was uncertain. We found very few live shells, but were told that they were easy to obtain when the water was low and clear.

The manager of the boathouse at Robinson Park told us of having seen a good bed of mussels here during clear low water. He also reported that where he used to live on the Ohio River they ate the "small sweet mussel," but the larger kinds were too tough for food, except that they could be used for flavoring soup.

Station E. Feeder canal from Robinson Park to Fort Wayne.—In the days of the Wabash and Erie Canal, the dam mentioned above was built across the St. Joseph River just below what is now Robinson Park, and a feeder canal was dug to convey the water from above the dam to the main canal at Fort Wayne. After the main canal had fallen into disuse this feeder was still used as a source of power for mills at the outskirts of the city, and the water was turned back into the St. Joseph River.

When Robinson Park was established the canal formed a charming water lane leading from the city out to it. About the summer of 1906 or 1907, however, the dam in the river broke and let the water out of the canal.

The dry canal bed offered one of the most remarkable opportunities possible for the study of mussel distribution within a small area. It was 6 miles in length and, with the exception of a few places below the general level, it dried up so quickly that the mussels are still left in their original positions in the mud on the bottom of the canal. The shells are half to two-thirds buried in the dried mud, the great majority of them with the posterior end directed northward—that is, against the current when the canal was full of water—and with the valves nearly closed, just as the animals died.

This region had been visited and preliminary studies made in the autumn of 1907, and it presented the same features that it did early in the summer of 1908—a long, dry, and cracked mud flat forming a vista of projecting shells, the short tracks the mussels had made during life being still distinct. In the canal bed it was possible to study all the species that had lived there, their abundance, distribution, and the like. Many of the young shells of *Lampsilis luteolus* exhibited brilliant rays; they appear to have been exceptionally highly colored.

Toward the upper end of the canal, in a place where the bottom was 15 feet wide, the mussels were counted for a stretch of 10 feet along the canal bed and the following species noted: *Quadrula rubiginosa*, 11; *Q. cylindrica*, 1; *Q. undulata*, 86; *Anodonta grandis*, 6; *Ptychobranchus phaseolus*, 1; *Lampsilis ligamentinus*, 5; *L. luteolus*, 6. The width taken was the total width of the bottom of the canal and was considerably wider than the space occupied by the mussels.

About a mile farther down the canal a space 10 feet square was measured off in the bottom of the canal and the following species

were found: *Quadrula rubiginosa*, 6; *Q. undulata*, 60, all rather small; *Pleurobema clava*, 1; *Alasmidonta truncata*, 2; *Symphynota complanata*, 2; *S. costata*, 5; *Anodonta grandis*, 15; *Obovaria circulus*, 4; *Lampsilis ligamentinus*, 5; *L. luteolus*, 1; *L. ventricosus*, 4. This gave a little over 1 shell per square foot. In 1908, in a square meter of bottom near the Rod and Gun Club, the following species were noted: *Quadrula rubiginosa*, 9; *Q. undulata*, 36; *Symphynota complanata*, 1; *Anodonta grandis*, 17; *Obovaria circulus*, 11; *Lampsilis iris*, 2; *L. ligamentinus*, 2; *L. luteolus*, 3, giving a total of 81 per square meter. In addition to these shells there were many small *Sphæriums*, the ground being paved with them, 34 *Campelomas*, and 23 *Pleuroceras*. The square meter referred to above represents, as nearly as could be judged, an average number rather than either extreme.

The general impression obtained concerning the abundance of various species is given in the table on page 37.

Figure 2, plate I, represents a portion of the dried canal bed near its upper end. It shows admirably the mud cracks formed on drying and the mussel shells still protruding in situ.

Realizing the value of an opportunity to study so extensive a tract with the mussels still in their original positions and in plain sight, several visits were made to the canal, and as a result the following conclusions were reached:

1. Each of the species found was well distributed throughout the entire canal; that is, there was no marked gathering together or colonizing of any one species to the exclusion of others. So fully was this true that a careful examination of a few rods of the canal bed anywhere was reasonably certain to yield specimens of all the species, except possibly one or two that were very rare. In this connection it must be kept in mind that the bed of the canal was very different from that of a river, in that it was practically the same throughout its entire length. It was all shallow mud, with little sand or gravel; the water was of nearly uniform depth, and the current was of uniform rapidity. In short, there was almost nothing except the consistency of the mud upon which a mussel could base any preference of locality. Slight differences in this respect caused an increase in the numbers of mussels in some places, but affected all the species equally.

2. The number of mussels which can find accommodation under fairly favorable conditions upon a definite area in the canal bottom may be judged by the counts on measured areas given above.

3. A canal makes an excellent breeding ground for mussels, as was particularly attested by the presence of a large number of younger examples among the adults, showing all stages of growth. The current in the canal appears to have been just fast enough, food material

Fig. 1.—Bed of Maumee River just below Columbia Street bridge, Fort Wayne, Ind., showing mussels killed by sewage from city gas works.

Fig. 2.—The dried bed of the Feeder Canal, showing mud cracks and mussel shells in situ.

Fig. 3.—Pile of shells, chiefly muckets, *Lampsilis ligamentinus*, containing 25 tons, gathered from the Maumee River near Fort Wayne, Ind.

constant and ample, the supply of water uniform the year round, and the bottom seems to have been well suited to a great variety of species. This gives the mussels a uniformly large size, while the shells at the same time are of extra quality and luster.

4. These facts would indicate that a canal would furnish one of the best locations that could be obtained for artificial propagation of mussels. Furthermore, the water in a canal can be drawn down from time to time without much trouble, thus allowing examination of the mussels. Examples suitable for breeding or for commercial purposes could then be selected easily and rapidly without in any way disturbing the others. Such possibilities are at least worthy of a careful consideration in future attempts at the artificial propagation of mussels.

The last visit to the canal was made on July 27, after a series of heavy rains. The canal bed was at this time under water for nearly its entire length, and was covered with grass and weeds that had sprung up in a short time and effectually concealed the shells. This visit threw light on a phenomenon which had proved quite puzzling during previous visits. Occasionally, shells of *Quadrula undulata*, only recently dead and with bits of flesh still clinging to them, had been found in dry places in the canal bed some distance from any pool. At the time it was hard to understand how they came to be there, as it seemed impossible that they could have " mudded up " and survived the long period following the breaking of the dam. This visit showed that during the high water of winter or spring the whole canal bed had probably been submerged, and that the mussels had migrated from the deeper portions at that time.

During our previous visits, also, a number of pools, comprising the deeper portions of the canal bed, were observed, and a few live mussels, chiefly *Anodonta grandis* and *Quadrula undulata*, had been noted near the edges, but the pools were not fully investigated.

On this last visit the pools were thoroughly investigated and were found to contain an abundance of molluscan life. Fine examples of the following species of mussels were secured: *Quadrula coccinea*, 1; *Q. rubiginosa*, many, deeply buried; *Q. cylindrica*, 1; *Q. undulata*, many; *Alasmidonta truncata*, 1; *Symphynota costata*, several; *Anodonta grandis*, a few; *Strophitus edentulus*, a few; *Ptychobranchus phaseolus*, 1; *Obovaria circulus*, 1; *Lampsilis iris*, 1; *L. rectus*, 2; *L. ligamentinus*, many, large and fine; *L. luteolus*, several; and *L. ventricosus*, 1, large. Among other mollusks, *Ancylus* was abundant and large, usually attached to the shells of living mussels. Algæ of various species were common, covering the water surface. In one place *Hydrodictyon* was exceedingly abundant.

This investigation was interesting and important, as it showed that mussels will live for long periods in shallow pools where they once

have obtained foothold, even though the conditions under which they once throve and multiplied have ceased. While it is true that mussels die rather quickly when placed in foul water or unfavorable conditions, both our investigations here and our experiments in transplanting elsewhere indicate that they can live for long periods where they probably would not naturally develop, and that they can easily be stored in pools of limited size.

Station F. Reservoir of the feeder canal.—This is an artificial pondlike area at the lower end of the canal and within the outskirts of the city of Fort Wayne. This reservoir, which originally connected with the canal, covers about an acre, and the water, which at the time of our visit was only a foot deep at most, probably never gets much deeper, as it can easily drain into the river below. The bottom of the reservoir is of a bare, yellowish clay, and there is a great deal of miscellaneous trash over it, indicating that it has been used to some extent as a sort of dumping ground. There were quite a number of mussels in this pond. *Quadrula rubiginosa* was common in the warm shallow water near shore, and on the date of our first visit (June 30) was remarkably active, almost every example being at the end of a long, curved track. They were quite high up out of the mud, and several had fallen over and were lying on their sides. *Quadrula undulata* and *Anodonta grandis* were also common, and there were a few *Lampsilis luteolus.* Some dead *L. glans* and one dead *L. ventricosus*, which quite closely resembled *L. capax*, were found along shore. More very young mussels were seen here than anywhere else. They were at the end of long, narrow tracks resembling snail tracks, in the shallow water along the north shore of the pond, and were nearly buried in the mud, only the posterior tip of the shell slightly projecting. Their presence indicates that the reservoir was used quite actively as a breeding ground for the mussels. There were a few fishes in the reservoir, chiefly carp and suckers, and boys were occasionally seen fishing there. Other mollusks, especially large *Campelomas*, were abundant.

The mussels of this place, especially the *Anodontas*, were more heavily infested with parasites than those obtained anywhere else, with the exception of some *Lampsilis alatus* taken at Grand Rapids. Ohio, which contained *Atax* in great numbers. The common mussel parasites, *Atax*, *Cotylaspis*, and *Aspidogaster*, were present in nearly every individual examined.

The reservoir was again visited on July 23, and it was found that the *Quadrula rubiginosa*, which on the previous visit were high up out of the mud and actively moving about, had by this time buried themselves deeply. It was also noticed that at the same date, in the pools of the canal itself, they were likewise deeply buried. It is probable that their great activity during our first visit was due to

restlessness caused by the warmth of the shallow water and that their action of deeply burying themselves was in anticipation of the drying up of the reservoir. A number of the *Anodontas* obtained at this time were examined as to food and parasites, with the following results:

No. 1.—Parasites: *Atax*, 3, in gill axils; *Cotylaspis insignis*, 1, in axil of inner gills; *Aspidogaster conchicola*, 2, in pericardial cavity. A small patch of *Plumatella polymorpha* on each valve. Gills empty, but ova in the body. Stomach contents ample, brownish green in mass, containing a few *Scenedesmus* and numerous globular organisms, probably *Trachelemonas*.

No. 2.—Parasites: *Atax*, 27, in axils of gills; *Cotylaspis insignis*, 8, in axils of inner gills; *Aspidogaster conchicola*, 8, in pericardial cavity. Shell deeply stained a salmon color on the inside, with a tadpole-shaped blister on the left valve near the siphonal opening. Considerable *Plumatella polymorpha* on the outside of the valve. Stomach contents fine greenish brown in mass, mostly of unrecognizable material, and containing several *Scenedesmus*, 1 *Pediastrum pertusum*, and 1 shell of rotifer *Anuræa cochlearis*.

No. 3.—Parasites: *Atax*, 43, between and among the gills, chiefly in the axils; *Cotylaspis insignis*, 2, axils of inner gills; *Distomum* of Osborn about 248, on outside of mantle, between mantle and shell; *Aspidogaster conchicola*, 8, in pericardial cavity; Sporocysts (*Distomum* of Osborn) innumerable, distributed thickly throughout the mantle. Stomach contents, chiefly minute green and black globules, probably *Cryptomonas*, and 1 diatom, *Pleurosigma*.

No. 4.—Parasites: *Atax*, 8 large, 2 small, in gill axils. The large ones were full of eggs. *Distomum* of Osborn, 58, 30 on the right side near the umbo ("right shoulder") and 28 on the left; *Cotylaspis insignis*, 9, in axils of inner gills; *Aspidogaster conchicola*, 2, in pericardial cavity. Stomach and intestine almost empty, but contained *Trachelemonas*, *Gamosphæria aponia*, and a spindle-shaped *Euglena*-like organism. Nacre stained a deep salmon color, with a good deal of *Plumatella* on the outside.

No. 5.—Parasites: *Distomum* of Osborn, 33 on the "left shoulder" and 35 on the right; sporocysts of that species innumerable throughout the mantle, the cercariæ escaping from them and present in large numbers; *Atax ypsilophorus* 32; *Atax*, small species, 18, between gills; *Cotylaspis insignis* 11, in axils of inner gills; *Aspidogaster conchicola*, 5, in pericardial cavity. The intestine contained numerous minute dark-green globules (*Trachelemonas?*), which were moving about actively. It also contained the *Euglena*-like organism, and *Anuræa cochlearis*, 1 empty shell.

No. 6.—Parasites: *Distomum* of Osborn, 23 on the "right shoulder" and 12 in the left; *Atax* 50, in the axils of the gills; there were many *Atax* eggs, which are minute yellow objects, on the inner side of the mantle. Two species of *Atax* present, a large and a small, both full of eggs. The eggs in the mantle were hatching, and the larvæ were present in the different stages of development; *Cotylaspis insignis* 4, in the axils of inner gills, and *Aspidogaster conchicola* 13, in the pericardial cavity. The shell had considerable *Plumatella polymorpha* attached; the nacre was stained a deep salmon, and there was a raised ridge on the right valve from the umbo downward and backward.

No. 7.—Parasites: *Atax intermedius* 14, in axils of gills, and with the eggs scattered on the inside surface of the mantle; *Distomum* of Osborn about 100, on the "shoulders"; *Cotylaspis insignis* 9, in the axils of the inner gills; *Aspidogaster conchicola*, 2, in pericardial cavity. The alimentary canal of this example was empty. Interior of the shell with a row of four salmon-colored

groups of knobs opposite each "shoulder" and extending from the hinge two-thirds of the way to the edge of the shell. Three straight ridges, also salmon-colored, on the left valve, radiating from the distal end of the row of knobs. The salmon marks in the nacre corresponded exactly with the position of the distomids in the mantle. There were three bunches of distomids corresponding to the three ridges on the left side.

No. 8.—Parasites: *Distomum* of Osborn, about 200 on the outside of the mantle at the "shoulders," but no sporocysts present. *Atax intermedius* 14, *Atax aculeatus* 3, and several examples of *Atax ypsilophorus*. The *Atax* contained large eggs, and all the animals were located between the gills; *Cotylaspis insignis* 2, in the axils of the inner gills; *Aspidogaster conchicola* 5, in the pericardial cavity. There was a good deal of *Plumatella polymorpha* on the shell. The color of the nacre was pretty uniform, but somewhat more intense in the region of the unbones, where the distomids were also thickest. Alimentary canal full of *Trachelemonas*, with a few diatoms and *Scenedesmus*. The *Trachelemonas* were very actively swimming about, although they had been in the stomach of the mussels for at least 36 hours.

No. 9.—Parasites: *Atax* 23, between the gills; the eggs abundant, and some young hatched: *Distomum* of Osborn 3, on "shoulders" as usual; *Cotylaspis insignis* 3, in axils of inner gills; *Aspidogaster conchicola* 7, in pericardial cavity. The alimentary canal contained rather numerous *Scenedesmus*, 1 *Pediastrum pertusum*, 4 *Anuræa cochlearis*, and 1 spindle-shaped *Euglena*-like object.

In a day or two after the visit to the reservoir in which these mussels were obtained, it was revisited. The pond was covered with a green scum, but there was no opportunity to examine it more fully.

The collections at this place were particularly interesting because of the knowledge obtained concerning stages in the life history of the distomid of Osborn, sporocysts of which were especially abundant in mussels no. 3 and 5. These matters are more fully discussed under our notes on parasites toward the end of this report. (See p. 61.)

Station FF. Feeder canal between the reservoir and the Maumee River.—The feeder canal with its reservoir may be regarded as a sort of auxiliary channel of the St. Joseph River from Robinson Park down to the city. The mussels were, however, much more evenly distributed in the canal bed than in the river bed. The latter was examined from the reservoir of the canal down to the mouth of the river, but only occasional mussels were obtained above Wagner Street Bridge.

Station G. St. Joseph River at Wagner Street, Fort Wayne.—At Wagner Street there was a very good shell bed, which was examined pretty thoroughly. The river here is shallow, with a gravel bottom, and the current during ordinary stages of the water is about 2 or 2½ miles an hour.

A little below this station there appeared to have been a fair bed of mussels; but sand was being hauled from the river in large quantities, and the disturbance was unfavorable to molluscan life.

The men hauled many shells with the sand. A fine example of *Lampsilis ventricosus* was observed spawning here on July 20. Just above where the men were hauling, *Quadrula rubiginosa*, a few *Symphynota costata*, some *Lampsilis luteolus*, and a large number of *L. ligamentinus* were seen. Where the men were at work a number of the rarer shells, *Pleurobema clava* and *Truncilla sulcata*, were obtained.

Station H. St. Joseph River just above its mouth.—One of the finest beds was just at the mouth of the St. Joseph River, extending upstream about 20 rods, and as the condition of the river was quite favorable this was examined several times. The bottom was of fine sand and the water from a few inches to about 3½ feet deep, and quite clear, so that the mussels on the bottom could be seen fairly well. There was nearly a bushel of shells on shore, which had been crushed by boys in search of pearls.

The mussels had been moving about to some extent and appeared to be, on the whole, quite active. While most of them were deeply buried and were headed downstream in their natural feeding position, a few were transverse to the current, and none showed the sharp line of demarcation on the shell that is usually found where the animals occupy the same position for a long time. Of this collection recorded in the table, 9 species, *Q. rubiginosa*, *Q. pustulosa*, *Q. undulata*, *S. complanata*, *P. phaseolus*, *L. rectus*, *L. ligamentinus*, *L. luteolus*, and *L. ventricosus*, represented by 208 shells out of a total of 341, were good button shells. This is a considerably lower percentage than a little farther down in the Maumee, as the proportion of marketable shells is considerably reduced by the abundance of the comparatively worthless *Symphynota costata*. The merchantable species were easy to obtain and also of large size and excellent quality. While we were at work on this shell bed on July 21, the clammers who had been working in the Maumee below entered the mouth of the St. Joseph. This date, therefore, marks the beginning of clamming operations on this river. The clammers had at the time about 800 pounds of shell in their boat, chiefly *Lampsilis ligamentinus*, which they had secured in the Maumee below.

MAUMEE RIVER.

During the autumn of 1907 preliminary investigations were made along the first few miles of the Maumee. Shells appeared to be fairly abundant, but were for the most part ignored by the local inhabitants. In general, no attention was paid to them except that they were occasionally used for fish bait, and people knew little about them. A considerable pile of scattered shells was seen in a yard adjoining the river, and the owner of the place said he had gathered the mussels to feed his ducks, which were very fond of

them. Among the shells found in the yard were some fine *Lampsilis ligamentinus*, and a rather thick ventricose form of *L. alatus*. There was no clamming for button shells in the river and little or no pearling.

In the summer of 1908 a prospecting trip along the first few miles of the Maumee discovered a clammer's camp, which will be spoken of more fully later on. (See p. 27.) The camp was visited several times during preliminary field work.

The boat was launched July 29 just below the Columbia Street Bridge in Fort Wayne, which marks the head of the Maumee, and August 9 we reached Miami, Ohio, 7 miles above Toledo, where the river enters Maumee Bay. The party proceeded downstream by easy stages, examining the river's bottom for mussels wherever there were indications of their presence, stopping overnight at one of the towns or villages along the river or at a convenient farmhouse. Defiance and Grand Rapids, Ohio, were the only places where any stay was made. At Defiance the Tiffin and Auglaize Rivers enter the Maumee, each of them nearly as large as that stream itself, and three days were spent examining them. At Grand Rapids an extra day was devoted to the long riffles below the dam. The old Miami and Erie Canal is still in operation from Defiance to Toledo. This afforded a way of getting past the dams and riffles and gave promise of being itself rich in mussels. As it kept so close to the river that the latter could be visited easily at any time, the party chose the canal for the remainder of the trip. The following is a summary of the stations with the species found at each and their relative abundance.

As previously stated, the stations were numbered consecutively, and the numbers appearing with the species represent the specimens of each that were obtained.

Station 1. Maumee River at its source.—This includes the first 2 or 3 miles of the river and the clammer's camp.

At the very head of the river, just below the Columbia Street Bridge, an immense bed of dead shells was found, forming banks and bars. The entire bottom of the river and the south bank for some distance out of the water were literally paved with shells, chiefly muckets (*Lampsilis ligamentinus*).

Some idea of the number of these shells can be obtained from figure 1, plate I, in which every one of the objects upon the bank is a dead shell. In all probability these mussels had been killed by the refuse from the gas works which are situated on the bank of the St. Marys a few rods above its junction with the St. Joseph. Spots of tar were found on dead mussels some distance below this point. The water was covered with an oily scum in places and a tarry odor was perceptible for several miles down the river.

The bottom of the river at its head is Devonian limestone, and the banks are of white clay; the average depth of the channel at the time examined was about 3 feet and the current about a mile an hour.

A mile and a half down the river was the clammer's camp. This was the only one on the river and had been established but a short time. The owner, Mr. H. S. Birge, had formerly lived on the Wabash, where shelling operations are active, and had done considerable clamming there. He had come to Fort Wayne to work on the construction of a canal, and finding this work slack at times, had naturally turned to the river and begun investigating its clamming possibilities. He reported clamming " fairly good but not as good as one might expect from the looks of the river." As the bottom was rough and stony with occasional snags and the water fairly shallow, he procured shells in the same fashion that they are obtained in parts of the lower Wabash—by scooping them up with a coal fork, the operator standing waist deep in water. In three weeks' time, with the help of his brother and two young boys, the clammers had gathered 25 tons of first-quality shells, mostly " muckets " (*Lampsilis ligamentinus*), with a sprinkling of good " long johns " or " black sand shells " (*Lampsilis rectus*), a few " pocketbooks " (*L. ventricosus*), etc. The shells were remarkably uniform in size and quality. There were few culls or worthless shells—less than a bushel. They consisted chiefly of *Lampsilis alatus*, a few *Quadrula tuberculata*, and an occasional *Unio gibbosus*.

Figure 3, plate I, shows a pile of shells, with the cleaning table in the background, and gives a fair idea of their size. In the matter of pearls and baroques this lot of shells gave very meager returns; there were no baroques worth saving, and only two small and comparatively worthless pearls in the whole lot. Mr. Birge was impressed with the size and fine quality of the muckets of this region.

Station 2. Five miles below Fort Wayne.—A fair bed of mussels was found here, with many dead shells along the bank. The water was shallow with almost no current, the bottom muddy with an abundance of algæ.

Station 3. Kern Reservation.—There was here a large bar projecting out of water and covered with dead shells which had evidently been washed out during river floods. The river was free from sewage and the water was quite clear, about 3 feet at the deepest, and with very little current. The bottom was of rounded gravel well covered in places with algæ, and many good-sized sponges. There were also large numbers of flatworms on the stones and many *Ancylus*, while crawfishes were numerous and hostile.

The mussels were well bedded and quite abundant, but not very large. A sample collection was preserved, after which the others were thrown back. This was the first station at which *Q. pustulosa*

was obtained in abundance, although a few fair-sized examples were found in the feeder canal in 1907. Mr. Kern, whose farm extends along the river here, says that the mussels appear to be dying off more rapidly than formerly, due, he thinks, to increased pollution of the river by sewage.

Station 4. Near New Haven, Ind.—Just above the New Haven Bridge is a long stretch of the river with clear shallow water and gravelly bottom. Here a fairly thick bed of mussels was found. The crawfishes were especially numerous and pugnacious, and many of them were seen eating small mussels. It could not be ascertained whether they had killed the mussels or were merely feeding on some that had died from other causes. All the shells obtained were rather small. The *Q. undulata* were peculiar in that the ridges were considerably broken up into isolated portions somewhat resembling tubercles.

Symphynota complanata, which was one of the characteristic shells of the feeder canal and of which we obtained examples in the mouth of the St. Joseph, may have been introduced into the Maumee River through the agency of the Wabash and the Erie Canal. At the town of New Haven we were told of a remarkable shell that some boy had found along the river several years before, and which had been preserved as a curiosity. An examination proved it to be a characteristic specimen of this species. This was the farthest down the Maumee it was seen or heard of.

Station 5. Below New Haven, Ind.—This station was near a sand bar just below a long riffle. The water was from a few inches to 3 feet deep, and the bottom sandy, with many pebbles. There was an immense number of crawfishes here, one of which was eating a dead *Q. undulata.* Only a few live mussels were found. Among the dead shells were one *Alasmidonta truncata*, one *Strophitus edentulus*, several *Obovaria circulus*, and several *Lampsilis rectus.*

Station 6. One mile below station 5.—A small pile of shells was found on the river bank opposite a house owned by a man named Nieter. Some boys had been searching for pearls and had thrown the emptied shells together. Upon examination we found only three species.

Station 7. Four miles above Woodburn, Ind.—After leaving station 6 no indications of shell beds were noted until we reached the vicinity of Woodburn, Ind. Four miles above that town is a large gravel bar on the north bank of the river, overflowed at high water and covered with dead shells. Several live mussels were found in a pool on the bar and one or two were out of water and still alive, showing that they had come there during the recent high water. The list includes both living and dead shells.

Station 8. Woodburn, Ind.—Near Woodburn is a long series of riffles known as Bull Rapids, where shells appear to be abundant, but would be difficult to obtain, except during very low water, on account of the rocky bottom and the swiftness of the current. There was a long bar here covered with dead shells, but although we waded about everywhere over the coarse sand and rocks of the bottom, covering a large area, we found only a few live mussels. The party stopped for the night with a Mr. Armbruster, just below this station, and he reported finding in his cornfield on the south bank of the river a large pile of mussel shells some distance from the water, and made up of the same kinds as those found in the river. The presence of bones and stone implements among the shells left no doubt that this was an Indian kitchen midden, and that the aborigines had used these mussels for food.

Station 9. Maumee Center Bridge.—Just above Maumee Center Bridge some men were busy hauling gravel out of the river bed. There was a fair number of shells in the gravel, though by no means enough to indicate a shell bed, and the men were of the opinion that there were not many in the river. The water was turbid at the place, the bottom of gravel, and the depth 3½ to 4 feet. The species noted were found in the sand along the shore.

Station 10. One mile below Antwerp, Ohio.—The next place at which the river was examined was about a mile from Antwerp, Ohio. Just below the town the river has a width of 250 or 275 feet, with low banks, and there is a long series of riffles. The bottom is covered with coarse gravel and loose rocks. There were many dead shells on bars alongshore, while the live mussels were rather scattered and deeply buried among the rocks and pebbles.

Station 11. Five miles below Antwerp, Ohio.—This station was along the bed of the river opposite the farm of a man named Curtis. A long sand bar with a number of dead shells was seen. On the bar were noted a few *Quadrula rubiginosa*, several *Q. cylindrica*, a few *Q. undulata*, a large number of *Pleurobema clava*, a few *Unio gibbosus*, a few *Obovaria circulus*, several *Lampsilis iris*, a few *L. rectus*, and a large number of *L. ligamentinus*, which was the most common shell. Just above the bar the water was deep and sluggish and below it was shallower and swifter. In the deeper water the shells were widely scattered and deeply buried and consequently difficult to find. In the shallow water on the slope of the bar they were also well scattered, but had been actively crawling about and were easily found at the end of the tracks they had made.

Station 12. Ten miles above Defiance, Ohio.—The water was quite deep here and the river banks steep; the place was used as a swimming hole. The bottom was rather solid, composed of fine mud and sand and covered with a growth of algæ, among which was a large

handsome species of *Chara*. No shells were seen on shore, and after examining a large area of the bottom only 3 live mussels could be found: 1 *Unio gibbosus*, 1 *Lampsilis alatus*, and 1 *L. luteolus*.

Station 13. Tiffin River, just above Defiance, Ohio.—Tiffin River is a large stream entering the Maumee about a mile and a half above Defiance, Ohio. We had heard that there were mussels in the stream, and Kirsch[a] has reported them as abundant in the lake at the head of the river, although he says nothing of the river itself. The backwater of the Maumee, caused by the dam below Defiance, extends for about 2 miles up this river, so that it was a very sluggish stream with almost no current. A light-green thin scum, resembling *Euglena*, flowed slowly down, streaking the central portion of the river.

The banks and bottom were yellow clay, the water turbid, and so far as we could observe aquatic vegetation was lacking. We ascended the river about 2 miles. No shells were seen on shore and considerable dredging brought up only 3 live mussels, 1 *Lampsilis alatus*, 1 *L. ligamentinus*, and 1 *L. ventricosus*. The river was full of brush and snags which frequently entangled the dredge. It is quite likely that mussels are more abundant higher up beyond the dead water.

Defiance, Ohio, was reached August 2. Here the Maumee and Cincinnati Canal goes southward through the State. At the time of our visit this canal was nearly empty, as the locks were being repaired. This canal was followed on foot for some distance into the country, but no traces of mussels of any kind could be seen along the shore or in the mud in the bottom.

Station 14. The Auglaize River, 2 miles above Defiance, Ohio.—The Auglaize River is fully as large as the Maumee, and joins the latter at Defiance, the old Indian fort for which the city is named having stood upon the point of land between the two rivers. The water is considerably clearer than that of the Maumee, and the dead water backs up the river for some distance. Just beyond the dead water is a series of short riffles. Here the water was quite shallow and the bottom composed of a slippery horizontal shale which had been used to some extent in the manufacture of cement. The river is further broken up by a number of small islets and pools. Many large dead shells were found on the bars. The mussels could obtain no foothold in the bottom of the main portion of the river, since it was of bare shale, but were found in the sand and gravel bars along the banks. Here they were congregated into dense beds. Nearly the whole surface of the bars was covered with dead and living shells, even among the roots of the water willows and other aquatic plants. The water was clear and the current moderate, making the collection

[a] Bulletin U. S. Bureau of Fisheries, loc. cit.

of specimens easy. Shells of all the species found were large, some of them exceptionally so, being the largest of their kind we had yet seen. This was notably true of *Symphynota costata* and *Alasmidonta truncata*. The shells were also of the finest quality and best luster, making them very desirable material for commercial purposes.

The *L. ventricosus* were buried rather deeply and were comparatively hard to dig out. *Quadrula pustulosa*, which had been dwarfed thus far in the Maumee, was here of good size. It will be noted that several species were found here which had not been encountered before, viz, *Quadrula lachrymosa*, *Plagiola donaciformis* and *elegans*, and *Obliquaria reflexa*. (See fig. 5, pl. II.)

Station 15. The Auglaize River, 4 miles above Defiance.—The success at station 14 determined us to try the river again 2 miles farther upstream. The bottom was much the same as at the previous station, except even more slippery and with fewer islets; and the only place the mussels could obtain any foothold was in sheltered coves alongshore, now on one side and now on the other, according to the current and swing of the river. The coves differed somewhat as to bottom, some being sandy or gravelly and others muddy. The shells found here included more of the smaller species than at the preceding station, although there were also some very large ones. On one of the fine gravelly bars a number of mussels, chiefly of the smaller species, were very actively crawling about in the shallow water; a recent shower had probably moved them out of their places and they were readjusting themselves. Here was found the only living example of *Truncilla sulcata* seen during the whole summer's work. In the protected coves with muddy bottom *Anodonta grandis* was the most common shell. *Lampsilis ligamentinus* was just beginning to show an approach to the gravid condition; the lower edges of the outer gills were becoming faintly distended and margined with black. *Ptychobranchus phaseolus* was considerably further advanced, the gills being thrown into wavy folds. There were many small schools of minnows here, which kept nibbling at our feet and ankles when we waded into the stream and which clustered eagerly about bits of bread which we threw into the water.

Among mussel parasites the marginal-cyst distomid was quite common, and there were a few *Atax* and *Cotylaspis* present. The *Anodontas* were heavily infested with *Atax* and the distomid of Osborn.

Station 16. Maumee River, 4 miles below Defiance.—Four miles below Defiance a State dam, 7 feet high, crosses the river. This dam, known also as the Independence Dam, was built by the State of Ohio to make the river a feeder to the Miami and Erie Canal, which enters the river at this point. In the palmy days of the

canal the town of Independence was located here at the dam, but when the railroad superseded the canal the town moved elsewhere. The water above the dam backs for 7 miles up the Maumee and about 2 miles up the Tiffin and Auglaize Rivers and forms a charming lakelike body of water below Defiance. This water is navigable for small boats and launches, of which there were a considerable number. The river is some 600 feet wide at the dam, and at the time of our visit a thin sheet of water was pouring over. We had been informed while at Defiance that there were many fine mussels below the dam. (See fig. 4, pl. II.)

Examination of the place proved the accuracy of our informant and showed that this locality was the richest collecting ground and supported a greater variety and abundance of life than any other stretch of the river. The river bed below the dam is a broad valley with a limestone bottom, the river being broken up into a great number of pools and channels dotted with little islands overgrown with willows. The water, sparkling and fresh after its race over the dam, seemed to make conditions exceptionally favorable for all sorts of aquatic life. The shores of the pools were edged with water willows, and the stones on the bottom were covered with a rich growth of algæ of various species and hues, some growing in long ropy masses; there were especially large clumps of *Cladophora*, lending a green color to the bottom, and numerous larvæ of caddis and stone-flies gluing the pebbles together. Many crawfishes were seen, and Bryozoa were common on the rocks. There were many anglers in high boots wading about in the racing currents. Flocks of black tern were flying overhead, the first we had seen.

Fringing the edges of the pools and islands were many rather small shells, chiefly *Plagiola elegans* and young *Quadrula lachrymosa* that had apparently been killed by fishermen for bait. By feeling about in the sand in the shallow water shells could be found in great numbers, and they were of fine quality and very large size. The *L. ventricosus* were the largest we had seen. Everything considered, these are the most important mussel beds in the river, and this is one of the places worthy of future study.

It was at this place we found a couple of pearls, which, on account of their minute size, were of no market value. They were, however, of considerable interest, as, on account of their position, they served to intensify the suspicion already entertained that pearl formation may be excited by the presence of the marginal cyst. We are of the opinion that this is an exceptionally favorable location for the carrying on of investigations along this line.

At the Defiance Dam we entered by means of a lock into the first stretch of the canal, which runs from Defiance to Grand Rapids, Ohio.

The canal has a moderate current and is a picturesque waterway, with a winding towpath on one side and a country road on the other.

Station 17. Maumee River at Florida Bridge, Ohio.—This is 4 miles below the dam, and the river had very much the same character as at the previous station, except that there appeared to be more water than at the very foot of the dam. There was not a great deal of current, and the water was clearer than any we had yet seen; the mussels could be clearly distinguished in 18 inches of water. The bottom was still of flat rock, so that it was only in favorable places that the mussels could anchor. They were fairly abundant, but considerably smaller than at the dam.

Station 18. Miami and Erie Canal, near Texas, Ohio.—Near a small village named Texas considerable dredging was done in the canal. The uniformity of bottom and absence of rocks or snags made the dredging very easy. The bottom was of soft black mud and the water about 5 feet deep with a moderate current. We found here a scattered bed of *Quadrula undulata;* every dredge haul brought up a few examples. These were large and rather plump, with a black epidermis, and approached more nearly to the form of *Q. plicata* than the very compressed brownish examples we had been finding hitherto. These shells bore colonies of *Plumatella polymorpha.* Below Texas there are two tedious locks in the canal, after which we entered the broad expanse of the Maumee above Grand Rapids Dam. At the last lock we saw valves of *Q. lachrymosa.*

Station 19. Maumee River above the Grand Rapids Dam.—Here, as at Defiance, the dam backs up the water for several miles, and at this place the river is widened to 2,000 feet or more. Mussels were reported plentiful in this dead water and a few hauls with the dredge verified the correctness of the report. The water here is 18 feet in depth and the bottom is covered with mud in which are patches of sand and rocks, and it is very good dredging, being free from snags. Only three species were obtained, but they were all large, fine shells.

Station 20. Maumee River below the Grand Rapids Dam.—This dam, like the one at Defiance, was built by the State of Ohio as a feeder for the Miami and Erie Canal. It is 5 feet in height and a little over 1,800 feet in length and interrupted at the center by an island 350 feet in width, known as Purdys Island. At the time of our visit (Aug. 17) no water was running over the dam, all the surplus escaping by the canal on the north bank of the river and a mill race on the south bank. The river bed below the dam is broken up into numerous channels separated by islands covered with water willows and other plants much as it was below Independence Dam at Defiance. Here, however, the bottom is a fine-grained sandstone which has been largely quarried for building purposes, with the

result that the channels are broken by long deep ruts and numerous pools. The water was very clear and in the shallower portions of the pools the shells could be seen distinctly. In one of the pools especially the mussels, crowded together and interspersed with numerous crawfishes, showed up so clearly that they made a recognizable impression on a photographic plate through about a foot of water.

The mussels here evidently have a hard time finding enough soil to hold them in place, and many appear to be washed out and down the river during high water. Several were seen lying on their sides on the bare ledges. (See fig. 4, pl. II.)

There was some pearl excitement at Grand Rapids, but it appeared to be confined chiefly to boys. The mussels can be very easily obtained, and shells, cut open by the pearlers, were strewed in large numbers over the rocks about the edges of the pools. Several of the boys that we saw had vials of small irregular slugs or baroques to sell, but they contained nothing of any value. The inhabitants of the place told us that button men had been there prospecting for shells and had offered $40 per ton for a species which we judged from their description to be the black sand shell, *Lampsilis rectus*. The shells of that particular species were so uncommon, however, that nobody thought it worth while to hunt for them.

There was some fishing in the pools below the dam, and mussels, especially small *Quadrula pustulosa*, were used for bait.

Station 21. Miami and Erie Canal at Grand Rapids, Ohio.—At the end of the dam opposite Grand Rapids we entered into the second stretch of canal, which leads from Grand Rapids to Toledo, Ohio. At the very head of the canal we dredged and examined the shores for signs of mussels. We obtained only one *Anodonta grandis* on the dredge, and this was heavily infested with the sporocysts of the distomid of Osborn. A few dead *Plagiola elegans* and *Obliquaria reflexa* were found on shore, probably left there by a muskrat. The canal is a pleasant stretch of water without any obstructions, running parallel with the river. (See fig. 6, pl. II.)

Station 22. Miami and Erie Canal, 4 miles below Grand Rapids.—About 4 miles down the canal, where a long fringe of upland forest borders the canal opposite the towpath, we came upon half a bushel of shells at the end of a burrow occupied by a mink or muskrat. The shells were all small. The *P. donaciformis* were of fine color and unusually large size. The finding of this pile of shells was a fortunate circumstance, as it contained a good number of shells belonging to species which we could not find in any quantity and which are not readily obtained by the dredge. Indeed, considerable dredging in the canal opposite the shell pile yielded only *Q. undulata* and *Q. lachrymosa*.

Fig. 4.—The Maumee River below the State Dam, Defiance, Ohio, the richest collecting ground in the river.

Fig. 5.—The Auglaize River, 2 miles above Defiance, Ohio, showing the small islets and pools containing dense beds of mussels.

Fig. 6.—A stretch of the Miami and Erie Canal, an excellent breeding ground for mussels, and an ideal place for artificial propagation.

As a usual thing, the muskrat appears to feed on other material, chiefly vegetables, during the summer, beginning its mussel diet more extensively in the autumn, and the first mussels killed are usually small.

From this station on, piles of shells along the shore indicated molluscan life, which would otherwise have escaped notice, and also the presence of muskrats.

Station 23. Miami and Erie Canal, 8 miles below Grand Rapids, Ohio.—Here, opposite a farm belonging to Mr. Neifer, a few hauls were made with the dredge, and a single *Quadrula pustulosa* and 15 to 20 *Q. undulata* were obtained.

Station 24. Maumee River, 4 miles above Waterville, Ohio.—The river here is much wider than at Grand Rapids; there are broad riffles and the bottom is mostly of flat limestone. There are only a few patches of sand in the bottom among the numerous islands, which are covered with willows, water willows, etc. Shells were fairly plentiful where they could obtain a foothold. There are many dead shells on the islands and a few small *U. gibbosus* and *P. elegans* on shore freshly killed, probably by a muskrat.

Station 25. Miami and Erie Canal, opposite station 24.—Two dredge hauls were made in the canal opposite the last station on the river, but only a single example of *Anodonta grandis* was obtained.

Station 26. Miami and Erie Canal, 1 mile east of Waterville, Ohio.—Just below the bridge which crosses both the canal and the river, 1 mile east of Waterville, Ohio, two dredge hauls were made. The canal here was about 6 feet deep and the bottom was of a rather soft black mud. The *Q. undulata* were rather inflated, with black epidermis and well covered with the bryozoan *Plumatella*, like those taken near Texas, Ohio.

Station 27. Miami and Erie Canal at Westcott, Ohio.—At Westcott, Ohio, a small village above Miami, a few dredge hauls were made in the canal, but only one *Quadrula lachrymosa* and a few *Q. undulata* were obtained.

At Miami, which is only 7 miles from Toledo, the Maumee was wide, with but few islands, and deep enough to be navigable for launches, of which there were many in evidence. There were large patches of *Nelumbo lutea* scattered about in the river. The shore was examined for a considerable distance but no shells were found. During low water the riffles are said to extend from Grand Rapids to within a quarter of a mile of Miami; the shells, therefore, would probably be about the same for the entire distance.

Station 28. Miami and Erie Canal below Miami, Ohio.—About a mile below Miami a temporary dam had been thrown across the canal to allow the making of certain repairs in the locks below. This dam

stopped all the water except a small overflow stream which trickled along the very deepest part of the canal. At one place, where a small stream came rushing over a miniature cataract, a dense school of young fish, which appeared to be the skipjack, *Pomolobus chrysochloris*, were crowded together making frantic efforts to leap up the fall.

In the shallow water of the canal many mussels were found alive, while along the exposed portions of the canal bottom an opportunity was presented for studying mussel distribution similar to that in the feeder canal at Fort Wayne.

By far the larger part of the bed of the canal was open to observation, the central stream being very narrow. At one place the canal when full had overflowed at one side, forming a large lagoon or backwater, in which the water had been from 6 inches to a foot in depth. The bottom of this lagoon was nearly covered with dead shells.

It was noticeable that *Quadrula undulata* and *Q. pustulosa* withstand a scarcity of water better than most of the other species. There were more of these two species alive in the water than all the others together, and in several places on the exposed sides of the canal examples of one or the other of these two species were found with the flesh still adhering to the shells, showing that these mussels had withstood drying up longer than associated species. The little *Anodonta imbecillis* was found for the first time in considerable numbers at this place, both in the deeper and shallower parts of the canal. The conditions of the canal also gave an excellent opportunity to get very young shells of some of the smaller species, such as *Plagiola elegans* and *P. donaciformis*.

In connection with the last station on the river may be considered shells obtained on the beach of Put-in Bay Island in Lake Erie. These represent species of the lake into which the Maumee flows and from which that stream may have received some members of its mussel fauna. No live mussels could be obtained at Put-in Bay except a few occasionally washed up by waves. About a mile below the bathing beach a number of dead shells were obtained, representing the species given in the table.

In this list the words "common" and "few" refer only to the relative number of shells found. Considered as a whole, shells at Put-in Bay were rather rare, and all seen were much dwarfed.

TABLE SHOWING DISTRIBUTION OF MUSSELS IN MAUMEE RIVER.

[NOTE.—Abun.=abundant; Com.=common; numbers denote the actual number of specimens found.]

Mussel species.	Lettered stations.								Numbered stations.										
	A	B	C	D	E	F	G	H	1	2	3	4	5	6	7	8	9	10	11
Quadrul atuberculata (purple warty-back)	2				Few.		1	1	Few.	1	5	2			7	Few.	Com.	4	1
Quadrula coccinea	1				Few.		2				7	1			Few.		1	2	2
Quadrula rubiginosa	Com.	4		Com.	Com.	Com.	16	15	Few.	Few.	107	2	2		2	Few.	Few.	Few.	Few.
Quadrula pustulosa (pimple-back; warty-back)		1					1	1	Few.		45	2	1				Few.		
Quadrula cylindrica (rabbit's-foot)	1				Few.			1							6	1			Few.
Quadrula undulata (three-ridge; blue-point)	Com.	9		Com.	Abun.	Com.	11	78	Few.	Com.	7	2		Few.	Few.	1		2	1
Pleurobema clava	1								Few.	Few.		2			Abun.	Few.	Abun.	2	Com.
Unio gibbosus (spike)	Few.						5	9	Few.						Com.		Few.	9	7
Alasmidonta truncata					Com.		1	2			2		1		Few.		Few.		
Symphynota complanata (heel-splitter; hackle back)					Com.			1											
Symphynota costata (fluted-shell; squaw-foot)	Abun.	7			Com.		13	86	Few.	2	22	22	6		Com.		Few.	1	
Symphynota compressa								1											
Anodontoides ferussacianus subcylindraceus			11																
Anodonta grandis				Com.	Com.	Com.		9									Few.		
Strophitus edentulus (squaw-foot)	1	1			Few.		2				1		1						
Ptychobranchus phaseolus	1				Com.		7	18				2					2	Few.	7
Plagiola securis (butterfly)									1										
Obovaria circulus	Com.				Com.		2	2	Few.	1	5	1	5		Few.	Few.	2		Few.
Lampsilis gracilis (paper-shell)								11			2					1	1		1
Lampsilis alatus (pancake)								5	Few.		1		1		1				
Lampsilis glans					Few.	Few.		1											
Lampsilis iris	Com.		1		Few.			2		4		1			Com.		Few.		Few.
Lampsilis rectus	1	18			Few.		1	9	Few.		6	2	7		Few.		2		Few.
Lampsilis ligamentinus (mucket)	Com.	72			Com.		36	60	Com.	Com.	24	71	4	Few.	Com.	Com.	Com.	Com.	23
Lampsilis luteolus (fat mucket)	Com.	14		Com.		Few.	11	22	Few.		8	1	3			1	Few.	1	4
Lampsilis ventricosus (pocketbook)		4			Few.	1	5	8	Few.	2		12	2	Few.	Com.	Com.			1
Lampsilis multiradiatus	1				Few.			1							1		Few.		
Micromya fabalis					Com														
Truncilla sulcata	Com.				Few.			3		Few.	1	1			Few.				

TABLE SHOWING DISTRIBUTION OF MUSSELS IN MAUMEE RIVER.—Continued.

[NOTE.—Abun.=abundant; Com.=common; numbers denote the actual number of specimens found.]

Mussel species.	Numbered stations.																	Put-in Bay.	FF.
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		
Quadrula tuberculata (purple warty-back)			4		Few.	2			2									Few.	
Quadrula coccinea			2		Com.	Few.			Few.										
Quadrula rubiginosa			20	Com.	Com.				Few.				Few.				Few.	Few.	
Quadrula pustulosa (pimple-back; warty-back)			15	Few.	Com.	Few.			Com.		Few.	1	Few.		1		Com.		1
Quadrula lachrymosa (stranger; monkey-face)			3	3	Com.		Few.	Com.	Com.		Few.		1			1	Com.		
Quadrula undulata (three-ridge; blue-point)			37	Com.	Com.	Com.	Com.	Com.	Com.		Few.	20	Few.		9	Few.	Com.	Com.	
Unio gibbosus (spike)	1		8	Few.	Com.	Com.			Few.				Few.					Com.	6
Alasmidonta truncata			2			Few.													1
Symphynota costata (fluted-shell; squaw-foot)			7	Few.	Com.	Com.			Com.				Few.				Few.		
Anodonta grandis			1	Few.					Few.	1				1	2		Com.		
Anodonta imbecillis																	Com.		
Strophitus edentulus (squaw-foot)									Few.									Few.	2
Ptychobranchus phaseolus			5	Few.	2	Few.												{Few. dwarf.}	
Obliquaria reflexa (warty-back)			1		Few.	Com.			Few.	Few.	Com.		Few.				Few.		
Plagiola donaciformis			1								Abun.						Abun.		
Plagiola elegans (deer-toe)			2		Com.	Com.			Few.	Few.	Com.		Few.				Com.		
Obovaria circulus			7															Com.	2
Lampsilis gracilis (paper-shell)			7	Few.	Few.				Com.								Com.	Com.	
Lampsilis alatus (pancake)	1	1	3	1	Few.	Com.		Few.	Com.				Few.				Com.	Com.	
Lampsilis iris																		Few.	
Lampsilis rectus			1	Few.	Few.	Com.			Few.									Com.	1
Lampsilis ligamentinus (mucket)		1	26	Abun.	Com.	Com.			Few.				Com.				Few.		
Lampsilis luteolus (fat mucket)	1		11	Few.		Com.			Com.									Com.	
Lampsilis ventricosus (pocketbook)		1	11	Few.					Com.									Com.	
Lampsilis multiradiatus						Few.													
Truncilla sulcata			1	1	Few.													Few.	

DISCUSSION OF MUSSEL SPECIES.

1. *Quadrula tuberculata* (Rafinesque). Purple warty-back. This is not a very common species of mussel in the Maumee or its tributaries, only a few occasional examples having been taken. It was most abundant in the upper portions of the river, near Fort Wayne, and down as far as Maumee Center Bridge. No living examples were obtained below Defiance, Ohio, and only a very few dead shells were picked up below here, the last one being obtained at Waterville, Ohio. All specimens seen were kept, and only about 52 were obtained in the Maumee system altogether. The range of this species is given by Simpson[a] as "Mississippi drainage generally; southern Michigan; San Saba County, central Texas." While it is in the main a Mississippi form, it is one of those species which occur occasionally within the St. Lawrence Basin, and although not usually a lake-dwelling species a few old valves were found along the shore of Put-in Bay, The Maumee examples show very little variation. Although most of them were rather small, some of the shells seen at the clammer's camp near Fort Wayne were quite large. The few mussels of this species obtained alive usually contained small baroques in the dorsal region.

This mussel is of no value for buttons on account of its color. In addition to being purple, the luster is usually dull. The epidermis, which is commonly brown, is somewhat tinged with green in examples from Maumee Center Bridge. In some places the distomid of Kelly, associated with dorsal baroques, is a common parasite. The examples found in the Maumee River, however, are comparatively free from this parasite.

2. *Quadrula coccinea* (Conrad). This species is not as common in the Maumee Basin as *Q. tuberculata*, only about 31 specimens having been obtained. It was more abundant in the upper course of the river, but dwindled out and finally disappeared; the greatest number (10) was obtained at Kern's Reservation, not far below Fort Wayne, and the last one was taken at Florida, Ohio, in the riffles below the bridge. It is a species common to both the Mississippi and the St. Lawrence drainage. The larger number of examples seen were white nacred, though a few were rosy.

The larger white-nacred specimens would make excellent button shells, classing with the pig-toes, though considerably thinner.

3. *Quadrula rubiginosa* (Lea). *Quadrula rubiginosa* is one of the most widely distributed of our fresh-water shells and occurs in a great variety of situations; it is found in lakes as well as in rivers. It is fairly common all along the Maumee and its tributaries (except the Tiffin, which was not thoroughly examined and in which few

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[a] Proceedings U. S. National Museum, vol. XXII, p. 795.

shells of any species were found). It was very abundant in the feeder canal and in its reservoir. A number of shells of this species were also found on the shore of Put-in Bay Island, Lake Erie.

Although during the summer's collection we obtained material exhibiting considerable variation, all examples found within the Maumee Basin were fairly constant in form, though some were short and humped. This species very closely resembles *Quadrula coccinea*, the only apparent difference being in the prominence of the ridge on the posterior umbonal slope; hence some specimens are difficult to classify.

Young shells of this species exhibit faint rays which disappear with age. The specimens obtained in the reservoir differed from most of the others in having a very satiny epidermis. The greater number of the shells have a white nacre, although in some cases it is yellowish or rosy. None of our examples are as rosy, however, as *Q. coccinea* frequently becomes. The flesh of this species varies from salmon or orange to deep red, the richness of its color probably varying with the nearness to the breeding season and the abundance of ova present; these latter are of a bright carmine color. Some specimens were found becoming gravid and one nearly ripe in the feeder canal July 27. On account of its commonness not all of the shells seen were collected; however, we obtained 112 examples from the Maumee Basin.

What seemed a peculiarity in the action of this mussel was the habit of burying itself in the early summer. On a visit to the reservoir of the feeder canal on June 30, the mussels were all projecting far out of the mud and actively moving about, while on July 23, at the same place, they were buried quite deep, and hard to find. They were also deeply buried in the feeder canal pools about the same date.

A probable explanation of this peculiar action is that the reservoir was quite shallow and the water became warm. The water becomes low during drouths, and the mussels may have gone down into the mud in anticipation of the pool going dry.

This species is sometimes more or less affected with *Atax*, though not badly. Those found in the reservoir were more affected than others.

Although its small size is something of a disadvantage, this species would make a fair button shell. It has good luster, and its comparative flatness would permit its being worked up economically.

Though there are a number of river shells superior to it, it is one of the best if not the best button species that would thrive well in ponds. A considerable number were weighed and measured, and the largest, obtained at the Defiance Dam, was 88 millimeters high by 306 millimeters long, and the dry shell weighed 101 grams.

4. *Quadrula pustulosa* (Lea). Pimple-back; warty-back. *Quadrula pustulosa* is another of the widely distributed mussels common to both the Mississippi and St. Lawrence drainage systems; but, although thus widely distributed, it is somewhat choice of its habitat. It shows a distinct preference for more or less sandy or gravelly bars with a live current. It does not usually form beds, but is generally more or less mixed in with other species. It was found throughout the length of the river, but most abundantly in the central portion. A few examples, some of them of good size, were found at Fort Wayne, especially in the feeder canal. The greatest number taken at one place was at Kern's Reservation, where 46 were obtained in a shallow bottom of sandy gravel. All these examples, and, indeed, nearly all found in the Maumee until we reached the Auglaize River, were small, dwarfed shells; those found in the Auglaize River and near the dam at Grand Rapids were of considerably larger size. A few of the shells were almost devoid of pustulations, and one small smooth shell, much produced forward and rounded, bore considerable resemblance to *Obovaria retusa.* The two largest examples obtained were 85 millimeters long and weighed (dry shell) 145 grams.

This is one of the species commonly used in button making, and where it reaches large size is fairly well adapted to that purpose. In the Maumee, on account of both their small size and their fewness, they are not an important item. Most of the examples secured were retained and numbered in all 156 shells.

5. *Quadrula lachrymosa* (Lea). Stranger; monkey-face. This species was found only in the lower courses of the river; none were encountered above the Auglaize. In that stream three examples, the first seen, were secured. From this point they were occasionally met with all the way down the river, and in the canal. Thirteen specimens were taken below the Defiance or Independence Dam, and below the dam at Grand Rapids, Ohio, 24 were obtained. This is the greatest number for any locality. The largest one seen was obtained here; its length was 115 millimeters and its weight (dry shell) 221 grams. All examples seen were retained, the total number being 46.

This shell is used in button making, and ranks in this respect along with the three-ridges. The irregular sulcation of the valves, however, puts it to some disadvantages in cutting, so that while it is an interesting and well-marked shell, it does not possess enough favorable qualities from the commercial point of view to make it desirable for propagation.

6. *Quadrula cylindrica* (Say). Rabbit's-foot. This has been regarded as a species of the Mississippi drainage, belonging principally to the Ohio, Cumberland, and Tennessee River systems. Only a few examples were found and these were in the feeder canal and upper

parts of the Maumee. It is therefore probable that they represent the result of migrations by way of the Wabash and Erie Canal. One example was found in the St. Marys River and four in the Maumee in the vicinity of Antwerp, Ohio; a few dead valves were occasionally seen, but not more than two or three at the most. None were found below the point just mentioned. In the feeder canal, where conditions were particularly favorable for a study of the fauna, four examples were found, and two fine valves, not mates, were obtained in the mouth of the St. Joseph. The shells found in the feeder canal were of an elegant compressed form with numerous triangular tubercles on the anterior portion, and represent the subspecies *strigillatus* B. H. Wright, which is considerably more attractive than the type form. They are rather dark in color, with green triangles, as is usual, and fine capillary rays. One example contained two *Atax*. This attractive species is not well suited to button making on account of its form and the fact that the nacre is frequently diseased; hence it is practically unknown to the trade.

7. *Quadrula undulata* (Barnes). Three-ridge, blue-point. With the exception of *Lampsilis ligamentinus*, *Quadrula undulata* is the most abundant species of mussels in the Maumee Basin. All the undulate mussels found were referred to this species except those at Put-in Bay, Lake Erie. Notwithstanding the statement made in nearly all the literature at hand that "the two species[a] are perfectly distinct and there is no need of confusing them," many examples were found that were hard to place. Different authors do not agree perfectly as to the differences between these species and, generally speaking, the characteristics given are rather vaguely expressed, a fault not due to the carelessness of describers but to the nature of the case. All descriptions seem to agree in stating that the umbones are more inflated in *plicata*, but we find this feature as variable as any other. In the large collection of shells of the Bureau of Fisheries belonging to these two types we have many intermediate forms and several series exhibiting almost perfect transition from one species to the other.

This species, as we have it, is exceedingly variable, so much so that in looking over the entire summer's collection it was possible to give the locality of a number of shells simply from their appearance.

Q. undulata was found to be fairly common along the river where there were any shells at all, and on account of its abundance only a small proportion of the shells seen were retained. Fourteen were obtained at the riffles in the St. Marys, where it was fairly common. In the St. Joseph River at Robinson Park and in the feeder canal it was abundant and attained large size; 10 examples were obtained from the St. Joseph and 23 were taken of the large number seen in the feeder canal. It also throve in the reservoir of the feeder canal.

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[a] *Q. undulata* and *Q. plicata*.

Very few were found in the upper Maumee. None were noted in the shell pile collected by the clammers near Fort Wayne and only 10 were obtained in the river above Defiance, Ohio. In the Auglaize River the species is quite abundant and 52 specimens were secured. It was fairly common in the Maumee below Defiance. Ten examples were secured at the Defiance Dam, 6 in the canal at Texas, and 16 near the dam at Grand Rapids. It was the most abundant shell in the canal below Grand Rapids.

From Defiance down the river and in the canal these shells were blacker and considerably more inflated than those above; the specimens found in the feeder canal at Fort Wayne were usually quite compressed and brownish in color, while those below Defiance were full and black, suggesting *Q. plicata.* These latter shells were usually overgrown with patches of the bryozoan *Plumatella polymorpha.*

This is one of the staple species used in button making, the nacre having a good luster and the shell being thick and heavy. The small end is beautifully iridescent and frequently of an attractive blue color.

This species, along with its relatives, is in good repute among pearl hunters. We found a few minute pearls and small rough baroques, but no more than in other shells. It is fairly free from parasites; a very few *Atax* were found. The nacre is frequently stained brown. As the species is hardy and thrives in a variety of conditions, especially in canals, it might be a good sort of propagate where better species would not thrive. The total number of examples obtained in the river was about 180.

In Lake Erie, at Put-in Bay, we found a dwarf species of shell, *Q. plicata hippopœa* (Lea), resembling this.

8. *Pleurobema clava* (Lamarck). Simpson[a] regards this as a shell of the Mississippi drainage and gives its range as "Ohio, Cumberland, and Tennessee River systems, reported from Iowa City, Iowa, St. Peters River, Minn., and from Nebraska." Call reports it from the St. Marys and from another stream in Indiana (St. Joseph) of St. Lawrence drainage. In the Maumee Basin it was nowhere abundant, but fairly well distributed along the upper course of the river. One was found above Bluffton Road Bridge, and in the St. Joseph River two dead shells were found, one quite large. Two shells were found in the Maumee near Fort Wayne, while at Maumee Center Bridge we obtained 12 moderate-sized specimens. At Antwerp two small shells were seen, and dead shells were still fairly common several miles below that place. None were seen as far down as Defiance, nor any below there, nor were any found in Lake Erie at Put-in Bay. The whole number of specimens obtained

[a] Synopsis of the Naiades, Proceedings U. S. National Museum, vol XXII, p. 746.

was 20. The Maumee specimens are brightly polished and can be distinguished by this feature from the rest of the summer's collection.

This is an exceedingly handsome shell, but of no commercial importance, as both its small size and peculiar form are disadvantageous. The nacre, though usually white, is occasionally of a beautiful warm pink.

9. *Unio gibbosus* (Barnes). Spike. *Unio gibbosus* was fairly common the whole length of the river. It is one of the species of wide distribution and considerable variability. Our specimens do not exhibit much variation, however. Most were of the solid, shortened, somewhat humped type. The long examples, which have procured for the species the name "spike," sometimes closely resemble *Lampsilis rectus*, from which they can be distinguished by the sculpture of the umbones and by the shape of the lateral teeth, while the short humped form is frequently almost indistinguishable from *Ptychobranchus phaseolus;* about the only way to tell them apart is by observing the color and texture of the epidermis, that of *U. gibbosus* usually being darker, and by the shape of the body cavity. One shell was found in the St. Marys, two in the St. Joseph near its mouth, and three in the Maumee near Fort Wayne. It was most abundant in the central portion of the river from Maumee Center Bridge to the bridge at Florida, Ohio, and was common in the Auglaize River. Lower down the Maumee it gradually disappeared, the last few shells having been seen at Grand Rapids, Ohio, below the dam. In all, 63 shells were obtained in the Maumee Basin. It appears to be one of the common shells in Lake Erie, 16 having been found on the shore of Put-in Bay Island. Both purple and white nacred forms were present. The greater number, about two-thirds, had white nacre, one had rosy nacre, one had purple nacre, white at the edges, and the others were intermediate between white and purple. Young examples showed delicate rays.

This species is of no commercial value, as even the white forms have the nacre quite dull. In some localities the distomid of Kelly, associated with dorsal baroques, is a common parasite, but they are not abundant in the Maumee.

10. *Alasmidonta truncata* (B. H. Wright). This is not an especially common shell in the Maumee Basin. According to Simpson[a] it is a Mississippi Valley species which has migrated into the upper parts of the St. Lawrence Basin. It is rather variable in form and is sometimes difficult to distinguish from *Strophitus edentulus*. It was found in the feeder canal and St. Joseph River at Fort Wayne. Occasional examples were encountered along the course of the river, as 2 at Kern Reservation, 1 at Maumee Center Bridge, 1 at Antwerp, Ohio. Three large ones were obtained in the Auglaize River

[a] Synopsis of the Naiades, Proceedings U. S. National Museum, vol. XXII, p. 671.

and three in the Maumee below the Independence Dam. The last example was found below the dam at Grand Rapids, Ohio. In all, 15 specimens were taken.

This shell is handsome and odd, brightly splashed with blue or green and greatly inflated. It is of no commercial importance on account of its thinness. The nacre is usually whitish, though frequently with a bluish tinge and occasionally a beautiful pink or rosy.

11. *Symphynota complanata* (Barnes). Heel-splitter; hackle-back. This species is common about Fort Wayne, being especially abundant in the feeder canal, where it was one of the most conspicuous members of the mussel fauna. Of the great number seen in the feeder canal 18 fine examples were taken; 2 were secured in the reservoir of the feeder canal and 5 in the St. Joseph River near its mouth.

This species is evidently an overflow from the upper Wabash drainage. Only one specimen was obtained in the Maumee River and that was at the very head near Fort Wayne; one which had been found at New Haven, about 7 miles below Fort Wayne, had been kept and was shown as a curiosity.

This shell was formerly not much used in button making, as it is usually rather thin for that purpose. Its broad flat surface and fair luster, however, are greatly in its favor, and more buttons can be cut out of one of its valves than from any other species except the large *Quadrula heros*. It appears to breed abundantly and bring forth large numbers of young. Gills of examples obtained in the Little Wabash River near Fort Wayne, September 26, 1906, were full to bursting with glochidia, which are brownish and give the whole mass a distinct brown color.

The species appears to have bred successfully in the feeder canal, as there were a great many young shells there. It would probably not thrive well in ponds, though a healthy example was seen in the reservoir of the feeder canal. It is not found in lakes, but is frequent in small streams with rather muddy bottoms, and is somewhat similar to *Anodonta* in habits. It is frequently the host of *Atax*, and is one of the species especially susceptible to infection by the parasite *Aspidogaster conchicola*, which inhabits the pericardial cavity, without, however, doing much apparent harm.

As this species lives where there is rather little current and thrives on a muddy bottom, it would probably be a valuable subject for cultivation. Its abundance in the canal suggests that it would respond well to artificial conditions.

12. *Symphynota costata* (Rafinesque). Fluted-shell; squaw-foot. This mussel was fairly common in the Maumee River throughout most of its length. One example was found in the St. Marys River

above the Bluffton Road Bridge, and 11 were obtained at the riffles. In the feeder canal 2 examples were secured. It was probably not uncommon there, but on account of its general abundance no more were taken. From 1 to 3 were found at most of the stations on the Maumee, so that it would be unnecessary and tedious to give its occurrence in detail. It was common in the Auglaize, where 13 examples were secured, and abundant in the Maumee below the dam at Grand Rapids, Ohio, where we obtained 23. One was found in the canal just below Grand Rapids. Some of the examples are beautifully rayed. The nacre is usually of a peculiar and pleasing yellowish shade. On account of the usual thinness of the shell, however, the species is commercially unimportant, few or none being used in the button business. Altogether we obtained in the Maumee Basin 125 shells belonging to this species.

13. *Symphynota compressa* (Lea). In the Maumee Basin we found only one example of this widely distributed species. This was found in the St. Joseph River near its mouth. The species is rather small and thin, and of no commercial importance.

14. *Anodontoides ferussacianus subclyindraceus* (Lea). This subspecies was found in only one locality in the Maumee drainage, and there it was the only species found except one fragment of *Lampsilis iris*. This was in a small stream, Spy Run, which enters the St. Marys at Fort Wayne. In this stream seven examples were found, all small dead shells. This species is of no commercial importance on account of the thinness of the shell.

15. *Anodonta grandis* (Say). This species delights in a muddy bottom and a slow current. It was rather common in such places as the feeder canal and its reservoir, and a few large examples (dead shells) were found along the St. Joseph River near Robinson Park. It was found only occasionally in the rivers; 5 were obtained at the riffles of the St. Marys River; 10 were taken of many found in the feeder canal; 12 were collected in the reservoir of the feeder canal. We found 8 in the St. Joseph River near its mouth. In the Maumee it occurred rather sparingly, 1 example having been obtained at the Maumee Center Bridge, 10 in the Auglaize River, 1 in the Maumee below the dam at Defiance, 5 below the dam at Grand Rapids, and 2 in the canal below Waterville. A number were seen below the dam in the canal at Maumee. Only a few of the examples seen were collected; the total number taken was 51.

The specimens from the feeder canal were unusually thick, appearing as if a second nacreous layer had been deposited.

Of all the species of mussel encountered, *Anodonta* was the richest in parasites, harboring the greatest number of species, and (except in the case of some *Lampsilis alatus* obtained at Grand Rapids which

contained great numbers of *Atax*) the largest number of individual parasites.

Most of the shells obtained were more or less stained red interiorly. This stain, caused by a parasite, the distomid of Osborn, varied greatly in extent, beginning in the umbonal cavity and extending from that region in two diverging lines, one anteriorly and the other posteriorly, ventrad. The V-shaped area thus formed gradually fills in with red until the whole surface is involved. This process has been quite fully described by H. L. Osborn[a] and by H. M. Kelly.[b] The minute distomids, showing pink against the mantle, were present in numbers varying from a few to several hundred.

Occasionally mussels of this species were found in which the distomids mentioned above had not yet escaped from the sporocysts. The shells of such mussels frequently had the nacre raised in sharp pearly projections, and in some cases the sporocysts seemed to have been overgrown with the nacre of the shell.

In addition to the distomid of Osborn, *A. grandis* also usually has a number of *Aspidogaster conchicola* in the pericardial cavity, several individuals of *Cotylaspis insignis* in the axils of the inner gills, and one or more species of *Atax* among the gills; even leeches are frequently found within the shells. The leeches are no doubt parasitic, as is evidenced by the fact that where a pile of freshly cleaned shells killed by muskrats were found under water on another occasion (at Lake Maxinkuckee) the leeches almost covered the insides of the valves.

On account of the thinness of its shell, *Anodonta grandis*, and indeed all the species of this genus, are of no value commercially.

16. *Anodonta imbecillis* (Say). This species has not heretofore been reported from the Maumee Basin. It was only infrequently found; one specimen was obtained on the shore of the St. Marys River, at Fort Wayne. After this none were seen until at the very end of the investigation, in the canal at Maumee, Ohio, below the dam; at this place 38 examples were taken. Their abundance here indicates that they were probably abundant also throughout the length of the canal, but do not "bite" at the dredge hooks. As none were found in the bottom of the feeder canal, it is probable that they do not occur there. This is a very pretty species, but it is of no commercial value.

17. *Strophitus edentulus* (Say). Squaw-foot. This species is not common in the Maumee Basin. Examples were occasionally found in the St. Marys River at Fort Wayne, in the feeder canal, and in the St. Joseph and upper Maumee Rivers. One was obtained at Grand

[a] Zoological Bulletin, vol. I, no. 6, 1898.
[b] Bulletin Illinois State Laboratory Natural History, vol. v, p. 406, 1899.

Rapids, below the dam. None were seen in the Auglaize River, nor in the Maumee at Defiance. One shell was found on the shore of Put-in Bay, Lake Erie. In all, only 8 examples were obtained in the Maumee Basin. It is of no commercial importance.

18. *Ptychobranchus phaseolus* (Hildreth). This species was not abundant anywhere in the Maumee Basin, but was scattered all along the length of the river. In the autumn of 1907 a fair number were obtained in the feeder canal. We found 16 good specimens in the St. Joseph River at Fort Wayne, 2 in the Maumee near its head, and 2 or 3 at occasional stations along the river. It was fairly common in the river below Antwerp, Ohio, where 10 shells were obtained at one station. Nine examples were secured in the Auglaize River, 2 in the Maumee below the dam near Defiance, and 3 at the bridge at Florida, Ohio, and 2, the last seen, were taken below the dam at Grand Rapids, Ohio. The examples obtained in the Auglaize August 8 were beginning to become gravid. In all, 53 specimens were secured from the Maumee Basin. Shells of this species were fairly common on the shore of Put-in Bay, where it was small but beautiful in color, luster, and form. The outer gills of gravid examples are remarkable for their folded and plaited appearance; the gills look like nests from which insect larvæ, like "wigglers," are ready to emerge. The nacre of some of the young shells is of a beautiful faint pink, but that of all the large old shells was white.

This shell has not been used to any extent, if at all, probably on account of the scarcity of supply, and it is not known to the trade. Its flatness, nearly uniform thickness, and excellent luster would make it worthy of experimentation in the button business. It would probably rank with the "butterfly," *Plagiola securis*, in that respect. The presence of a number of young shells in the feeder canal indicates that it might be easy to propagate in artificial channels.

19. *Obliquaria reflexa* (Rafinesque). Warty-back. This species was first encountered in the Auglaize River, where 1 example was secured. Below the Defiance Dam 3 were obtained; 1 was found at Florida Bridge, and 3 at Grand Rapids below the dam. In the stretch of canal below Grand Rapids it was apparently abundant. One was picked up on the shore at the very entrance of the canal and 22 in a pile left by a mink or muskrat along the side of the canal. A few were found in the canal below the dam at Maumee. This species, being quite thick and of good luster, is used to some extent commercially, but on account of its small size a shell yields only a few buttons.

20. *Plagiola donaciformis* (Lea). The first example of this species was obtained in the Auglaize River. No others were seen until we reached Grand Rapids, Ohio, where 1 was found in the Maumee below the dam. In the stretch of canal near Grand Rapids it ap-

peared to be fairly common; 10 shells were taken from a pile left by some predaceous animal, and of a large number seen in the canal below the dam at Maumee 14 were secured, some of them quite young and small.

This is one of the most beautiful of our fresh-water shells, and the markings are very attractive. It is too small to be of any importance commercially.

21. *Plagiola elegans* (Lea). Deer-toe. No examples of this species were seen until the Auglaize River was reached, where we found 10. It was fairly common in the river and canal below this point. Living mussels and shells of some recently killed were very common in the Maumee below the dam near Defiance.

Of many examples seen we obtained 17 shells here. Below the dam at Grand Rapids, Ohio, we secured 6 shells, and at the pile of shells near the canal bank, which has been frequently referred to, we obtained 49 shells of this species. Some were seen along the shore of the Maumee 4 miles above Waterville, and it was common in the canal below the dam at Miami.

This is one of the prettiest of our fresh-water bivalves, but it is too small to be used much for buttons, though the largest examples are sometimes utilized. By clammers it is called the "deer-toe." It is fairly constant in form, but varies considerably in color and markings, the ground color being sometimes yellowish and sometimes green. The rays are often broken up into V-shaped blotches. The total number of examples collected was 97.

22. *Plagiola securis* (Lea). Butterfly. Of this species only 1 example, a large coarse specimen closely resembling some of the shortened and flattened forms of *Lampsilis ligamentinus*, was secured. This is a species belonging to the Mississippi drainage, and it is one of the most valuable shells for buttons. The specimen was obtained at the clammer's camp near Fort Wayne and was from the upper part of the Maumee.

23. *Obovaria circulus* (Lea). There appears to be considerable confusion among authors regarding the three so-called species *Obovaria circulus*, *O. lens*, and *O. leibii*, and by some authorities the two last named are regarded as subspecies of the first. We obtained the small inflated *O. leibii* on the shore of Put-in Bay Island. In the Maumee we obtained flatter, larger shells, which are similar to those in the collection of the Bureau from the Ohio and Tennessee Rivers. This species (*circulus*) occurs occasionally throughout the length of the Maumee. Three examples were found in the St. Marys River at Fort Wayne. It was fairly common in the feeder canal, where 16 specimens were secured, and in the St. Joseph River near its mouth, where we obtained 10. Six examples were obtained at Kern Reservation, five at Maumee Center Bridge, and 14 in the

Auglaize River, in addition to occasional shells picked up here and there. The last one seen was at Grand Rapids below the dam. The whole number obtained in the Maumee Basin was 60. This species is frequently infested with the distomid of Kelly, and contains small dorsal baroques. Diseased shells with one or both valves roughened and yellow on the inside were quite common. The shell is usually too small to be of much use commercially, but it has a beautiful luster, which continues in dead shells when exposed to the weather longer than in any other species observed. The nacre is usually white, though in some instances it is pink or rosy.

24. *Lampsilis gracilis* (Barnes). *Lampsilis gracilis* is fairly common and well distributed in the Maumee Basin, but is nowhere particularly abundant. Seven examples were obtained at the riffles in the St. Marys River and three in the St. Joseph near its mouth. In the upper part of the Maumee River it is rather scarce; only 1 was taken near Fort Wayne, 1 at Maumee Center Bridge, and 1 below Antwerp, Ohio. In the Auglaize River it was fairly common; 13 were obtained there. In the Maumee below the dam near Defiance it was rather abundant, 19 being found at that place. It was also abundant at Grand Rapids below the dam; here 16 were secured, and 2 in the canal below Grand Rapids. It was quite common in the canal below the dam at Miami, Ohio, though none were collected there.

In all, 63 examples were secured, and 10 additional dwarfed specimens on the shore of Put-in Bay Island, where it was quite common. This is one of the most iridescent shells we have, the posterior portion shading into a fine rainbow blue and purple. It is of no commercial value, however, on account of the thinness of the shell, which usually cracks badly in drying.

25. *Lampsilis alatus* (Say). Pancake. This species is of occasional occurrence in the Maumee Basin, but not abundant. Along the upper parts of the basin they were rather rare. Three were obtained in the St. Joseph River at Fort Wayne, and 1, small, in the Maumee, not far below its source. In 1907 several examples were obtained in the Maumee near Fort Wayne. A few scattered specimens were found below Antwerp, Ohio, and 1 in the Tiffin River a half mile above its mouth. Three were taken in the Auglaize and 11 large ones below the dam near Defiance, where it was beginning to become common. Three were found at Florida Bridge. Below the dam at Grand Rapids, Ohio, it was one of the most common shells and great numbers that had been opened by pearlers were seen on the rocks. We secured 23 examples here. A few were found in the second stretch of canal and in the Maumee above Waterville, Ohio. It was common in the canal below the dam at Miami, Ohio. In all, 56 specimens were taken in the Maumee Basin. At

Put-in Bay Island, Lake Erie, 10 small dwarfed examples were found; it appears to be common there.

The Maumee Basin examples, especially those obtained in the upper course of the river, differ from the usual type of the upper Mississippi River specimens in being considerably thicker, shorter, and more inflated. *Aspidogaster conchicola* is a fairly common parasite in the pericardial cavity, and the examples seen at Grand Rapids were infested with *Atax* to a remarkable degree, some individuals harboring nearly a hundred of the mites apiece.

There is a great deal of variation in the color of the nacre of this species, from pink to rich coppery red. Some of the shells were beautifully iridescent. On account of its color and the thinness of the shell it is of no use for buttons.

In the upper Mississippi, where this species thrives in great numbers, it forms the bulk of the cull shells left on shore, and on beds devoted to commercial purposes would probably be regarded as a nuisance. Richly colored baroques, usually of small size, occasionally occur in this species.

26. *Lampsilis glans* (Lea). This small, inconspicuous species is very likely to be overlooked in collecting, and is probably more common and more generally distributed than reports would indicate. It inhabits both ponds and rivers. In the Maumee Basin only 6 examples were secured—4 in the feeder canal, 1 in the reservoir, and 1 in the St. Joseph River near its mouth. All were dead shells picked up on shore.

27. *Lampsilis iris* (Lea). This attractive little shell does not appear to be common in the Maumee Basin. Two examples were secured in the St. Marys River above Bluffton Bridge, 4 in the St. Joseph near the mouth, 2 in the feeder canal, and 1 at Maumee Center Bridge, making 7 in all. It is probably more common than collections would indicate, as it is frequently found in abundance late in the fall after muskrats have begun collecting, where it has been difficult to find in numbers before this. It seems to be one of the favorite articles of diet with the muskrat.

28. *Lampsilis rectus* (Lamarck). While not particularly abundant, this is a fairly common and well-distributed shell in the Maumee Basin. Its distribution is so general that it is unnecessary to give details. It was quite common in the riffles in the St. Marys, and present in the feeder canal, St. Joseph River, along the Maumee, and in the Auglaize. Nearly every example seen was kept. In all, 63 were taken in the Maumee Basin and 3 in Lake Erie at Put-in Bay. Only a few young were seen, and a few gravid ones were obtained. The young are more or less distinctly rayed; in the adult the epidermis is about uniformly black, but the rays are represented by fine

plaitings. The female shells are more or less inflated and produced postero-ventrally, so that the ventral outline is somewhat arched.

Generally speaking, the color of the nacre is variable in this species; in some localities many of the shells are pink or purple. The great majority of the shells in the Maumee Basin are white, though the cardinal teeth may be pinkish, pinkish-purple, or purple. *Cotylaspis* is a frequent, and *Atax* an occasional, parasite. In a number of examples the nacre near the cardinal teeth was black and diseased. *L. rectus* reaches quite a large size in this basin; the largest example was 172 millimeters long and the dry shell weighed 375 grams.

On account of its relative scarcity the value of this species as now occurring in the river would not amount to much. It is, however, the most valuable indigenous species so far as price per ton of shell is concerned. In luster it is not greatly inferior to *L. anodontoides*, the most valuable of the fresh-water mussels. Its elongate form makes it as well suited to the manufacture of knife handles as *L. anodontoides* and for pocket knives the purple or pink nacred shells would not be so objectionable as in the manufacture of buttons, so that the advantage the other species has lies chiefly in the attractive color of its skin. At Grand Rapids we were told that a price of $40 per ton was offered for these shells. As this species lives under widely different conditions, such as rivers, canals, and even lakes and ponds (though it is usually dwarfed in lakes), it would be one of the most, if not the most, promising species with which to attempt artificial propagation in the Maumee.

29. *Lampsilis ligamentinus* (Lamarck). Mucket. This is by all means the most common shell in the Maumee Basin, occurring so frequently in the river that it would be both needless and tedious to go into details. At Fort Wayne it was common in all three rivers—the St. Marys, St. Joseph, and the Maumee—and in the bed of the feeder canal. It formed the great mass of the 25 tons of shells collected by the clammers at the head of the Maumee. At Fort Wayne it reached its maximum development, and though not actually immense, it was quite large and heavy, as heavy indeed as could be worked up profitably. The shells decrease in size as we go down the river, so that those in the middle portion are of only medium size. Those in the Auglaize River were fairly large. Although *L. ligamentinus* was found at most of the points examined for the whole length of the river, it became scarcer and showed a tendency to disappear from the lower stretches. It was not common in the second stretch of canal, though a few were seen in the canal bed below the dam at the very end of the trip. Only a small portion of the great number seen were taken; however, we saved 282 examples. A number of the shells were measured and weighed, of which the largest was

145 millimeters long and weighed 467 grams. The nacre of all the shells was white.

L. ligamentinus, the mucket, while not the very best of button shells, is not greatly inferior to the best, and on account of its commonness and favorable shape and size is the most common species in commercial use. In the upper Mississippi it occasionally has to be discarded on account of its pink nacre, but this feature is wholly absent from Maumee shells. Perhaps 90 per cent of the shells of the Maumee Basin that possess commercial value are *L. ligamentinus.*

This species is rather free from parasites. A few *Atax* frequently occur, but *Cotylaspis*, *Aspidogaster*, and the other parasites found so frequently in the thin-shell mussels, are usually rare or absent here. Encysted distomids are fairly common, though hardly so common as in *L. ventricosus.* They are usually found about the edge of the mantle, though they may also be distributed throughout the body. The common form, designated in this report as the marginal-cyst distomid, is of especial interest in this species, as it is occasionally the cause of the formation of pearls.

This species was not usually found gravid until late in the season. At the beginning of the Maumee investigation, in June, only a few examples were gravid, but the greater number were barren. As we proceeded down the river, it was noticed that in the Auglaize River, August 8, the gills had begun to fill with glochidia and had a faint blackish edge. On a visit to the riffles of the St. Marys on September 27 a large number of the mussels were found to be gravid.

Lampsilis ligamentinus is one of the most easily propagated of fresh-water mussels, and where it produces a heavy shell and white nacre, as it does in the Maumee, is one of the most valuable species for propagation.

Although well-marked specimens of *L. ligamentinus* are easily distinguished from the following species, *L. luteolus*, one frequently finds shells which are difficult to identify, apparently standing somewhere between the two.

30. *Lampsilis luteolus* (Lamarck). Fat mucket. *Lampsilis luteolus* was found in about the same situations as *L. ligamentinus* but not in such abundance. Most of the examples seen were collected and the number of shells in our Maumee collection is 134. None of our specimens are of the variety *rosaceous*, which is a form belonging to the St. Lawrence drainage.

Unlike *L. ligamentinus*, this species is usually abundant in lakes, as well as being an inhabitant of rivers. It is indeed one of our characteristic lake shells. We obtained a number from Put-in Bay Island, Lake Erie, but they were rather small, as is usual with lake-dwelling individuals. The examples found in the St. Joseph River and the feeder canal were remarkably large and fine. This species

appeared, like many of the others, to become smaller as we proceeded downstream.

L. luteolus is subject to infection by the same parasites as those which attack *L. ligamentinus*, viz, *Atax* and occasionally *Cotylaspis.* One example obtained in the mouth of the St. Joseph River contained a number of *Bucephalus polymorphus.*

This shell has nacre of about the same quality as that of *L. ligamentinus*, but the shell is usually smaller, and has more lateral curvature, so that it can not be worked up so advantageously in making buttons. It is well adapted to the manufacture of fancy buckles, however.

31. *Lampsilis multiradiatus* (Lea). This very attractive little mussel was not common in the Maumee Basin, and nearly all those found were dead shells, so nothing was learned concerning its habits. Only 9 examples were found, and these were in the upper two-thirds of the river basin, in the St. Marys, St. Joseph, and Maumee Rivers, and in the feeder canal. In 1907 a fair number were found in the feeder canal, and it had apparently thriven there to some extent. It is of no commercial importance. The species is a resident of lakes as well as rivers.

32. *Lampsilis ventricosus* (Barnes). Pocketbook. This shell, though not especially common, occurs rather frequently in the Maumee Basin. At the riffles of the St. Marys 7 large examples were found. Very fine examples were also obtained in the feeder canal. In the reservoir of the feeder canal a fine but small specimen was found, pretty closely resembling *L. capax.* In the mouth of the St. Joseph River 18 were secured. Occasional examples were obtained all the way down the Maumee; in the Auglaize 14 fine specimens were taken. The largest ones found were in the Maumee below the dam at Defiance, and it was also common below the dam at Grand Rapids, and 2 more were secured in the Maumee above Waterville, Ohio. Altogether 83 examples were obtained.

This shell also lives in lakes and 12 were obtained in Lake Erie at Put-in Bay, all dwarfed.

Although well-marked specimens of this species are easily recognized, it has many deviations from the typical form. Some closely approach *L. capax*, and we have seen shells from Lake Maxinkuckee which seem to lie between this species and *L. luteolus.* In other localities it appears to run into a species which in its typical form is known as *L. ovatus.* However, in the Maumee Basin it is well marked and fairly uniform.

L. ventricosus is used to some extent in the button business, but it is quite frequently too thin for this purpose.

In spawning season this is a very striking shell, the breeding mussel projecting long vividly colored flaps from the mantle and mov-

ing these with a spasmodic motion, while the animal lies on its back. The spawning season does not appear to be strictly confined to any particular season of the year, but spawning individuals can occasionally be found throughout the summer. One was observed in the St. Joseph River at Fort Wayne on July 20.

The principal parasites of *L. ventricosus* are *Atax*, usually few in number, the distomid of Kelly which is frequently present but never numerous, and the marginal-cyst distomid, which is occasionally present in great numbers in the margins of the mantle and throughout the body.

33. *Micromya fabalis* (Lea). This is the smallest and one of the most attractive of fresh-water mussels. It is rather rare in collections, on account of its small size being easily overlooked. It was exceedingly abundant in the Feeder Canal; in 1908 we obtained a half dozen examples, and in 1909, by going over the ground thoroughly in search of this particular species, several hundred were secured.

34. *Truncilla sulcata* (Lea). Scattered valves of this species were seen along the shore of the St. Marys and Maumee, and now and then whole shells. Shells and valves were found on the shore of the St. Marys above Bluffton Street Bridge, along the St. Joseph near its mouth, and in the Auglaize River. Only 1 living example was found, and this was in the Auglaize. In all only 15 shells were obtained.

Truncilla triquetra was not found in the Maumee Basin, but we picked up several vales on the shore of Put-in Bay Island.

GENERAL DISTRIBUTION OF SHELLS IN MAUMEE RIVER.

In general, as to distribution of mussels in the Maumee River, certain species were found to diminish in number or size, or both, in a downstream course.

Quadrula tuberculata diminishes in both number and size until in the lower part of the river only a few dead and rather small shells were obtained. Dwarfed specimens were also found at Put-in Bay.

Q. coccinea gradually diminishes and finally disappears at Grand Rapids, Ohio; it was found at Put-in Bay.

Q. rubiginosa greatly diminishes in numbers, but a few remain until the very last.

Q. cylindrica, sparingly present around Fort Wayne, was not found far below Antwerp, Ohio; no living specimens were obtained in the Maumee.

Pleurobema clava diminishes in numbers and disappears at Defiance, Ohio.

Symphynota complanata was common and large in the feeder canal and is occasional in the St. Joseph at Fort Wayne. One speci-

men was seen at New Haven, Ind. We ourselves found none in the Maumee, except at its very head.

Ptychobranchus phaseolus decreases in numbers and disappears at the very last near Miami, Ohio. Dwarf examples were found at Put-in Bay.

Obovaria circulus diminishes rapidly in numbers, and the last one was found in the Auglaize River at Defiance, Ohio.

Lampsilis multiradiatus, fairly well distributed in the upper part of the river, wholly disappeared at Defiance.

L. ligamentinus decreased in number more than in size, but diminished considerably even in size.

Truncilla sulcata, never very common, was not found below Defiance, Ohio.

The following species increase in number or size, or both, with the descent of the river:

Quadrula pustulosa increases both in number and size until it is fairly common below Grand Rapids, Ohio.

Q. lachrymosa first appears in the Auglaize a little above Defiance and becomes quite common in the lower part of the Maumee and in the canal.

Unio gibbosus increases both in size and number and becomes one of the most common forms in the lower part of the river.

Anodonta imbecillis appeared in considerable numbers at the very last, in the canal below the dam at Miami, Ohio.

Obliquaria reflexa first appeared in the Auglaize River, near Defiance, and became fairly common below there; the same may be said of *Plagiola donaciformis* and *Plagiola elegans*.

Lampsilis gracilis shows considerable increase both in numbers and size. The same may be said of *Lampsilis alatus*, of which very few were found at Fort Wayne, while it was abundant in the lower stretches of the river.

The following species are of about equal size and distribution throughout the entire length of the river:

Quadrula undulata was fairly common everywhere. It prefers a solid bottom overlaid with a thin stratum of rather soft mud, and wherever these conditions were encountered it was pretty sure to be found.

Symphynota costata was also fairly common everywhere; it increased somewhat in size as we descended the river, the examples found in the Auglaize being the largest obtained.

Anodonta grandis was nowhere abundant, but was found at nearly every station. It prefers a soft muddy bottom.

Lampsilis iris was rare everywhere, but was found all along the river.

L. rectus was nowhere found in abundance; the examples collected near Defiance were especially large and of fine quality.

L. ventricosus was nowhere abundant, but was found occasionally all along the river.

Of exceptionally rare shells, *Plagiola securis* was represented by only 1 specimen, obtained at the clammer's camp near Fort Wayne. In searching over the pile of shells found in the poultry yard referred to in the early part of this paper, it is believed that an example of *Unio crassidens* was seen, but as the shell does not appear in our collections its presence in the river can not be predicated with certainty.

In his paper on "The hydrographic basins of Indiana and their molluscan fauna,"[a] Dr. Call gives a list of 27 species of Unionidæ from the Maumee River; of these, 5 species, viz, *Quadrula heros*, *Alasmidonta calceola*, *Obovaria retusa*, *Obovaria ellipsis*, and *Lampsilis subrostratus*, were not seen by us.

FOOD OF THE MAUMEE MUSSELS.

The character of the food of mussels may be better appreciated after a short account of the method of feeding.

If one looks at a mussel in its natural position in the water one of the first things to attract the attention is two openings, one large and usually conspicuously fringed with elongate papillæ, the other smaller and fringed or not, according to the species. These openings project from the posterior or sharp end of the mussel which is directed upward from the bottom. The larger fringed opening is toward the ventral portion of the mussel and is an incomplete tube formed by portions of the mantle placed together. This is the inhalent opening, and here water is taken into the gill chambers by means of waving cilia which beset the gills, mantle, and other parts of the body bordering on the mantle chamber. The water thus brought in contains oxygen and food particles. The small cilia move the particles up to the anterior end of the body between the large labial palps or lips, which form a sort of funnel to the mouth. Here the food passes through the short gullet into the stomach, and thence into a long convoluted alimentary canal, which finally ends at the smaller of the two openings noted above, the exhalent aperture.

There are minute pores in the gills, and through these the water is forced by cilia into the exhalent aperture, from which it returns to the lake or stream in which the mussel lives. Large robust mussels are able to produce quite a strong current, but this is usually not visible in the rippling water where they naturally live. It can be best observed in large river mussels removed from their native stream

[a] Proceedings Indiana Academy of Sciences, 1896, pp. 248–257.

and placed in the calm shallow waters of a lake. It is probable that these mussels breathe extra heavily in the less highly oxygenated lake water. The current from the exhalent siphons boils up violently and is ejected intermittently at more or less regular intervals.

In many mussels there is no direct communication between the gill chamber into which the water, bearing solid particles, enters, and the suprabranchial chamber from which it is ejected through the exhalent aperture. Some mussels have the gills free above posteriorly, so that the two chambers have direct communication, and in these it is possible for the mussels to shunt solid particles directly from the gill chamber to the chamber above without passing through the alimentary canal. We have no evidence, however, that this is ever done. The mussel probably exercises little choice as to the nature of its food. The papillæ which fringe the edge of the inhalent orifice are supposed to be water-testing organs, and the mussel can close itself against foul water or against positively objectionable material. In the feeding mussel, as observed in the stream or lake, there is no appearance of nicety or fastidiousness as to the particles swept in; the wide open, immobile, and expressionless lips admit the general current and its diverse minute population with a catholic impartiality. The alimentary canal of the mussel is usually filled with a sort of impalpable or sometimes gritty mud, and mixed in with this are found scattered organisms of various sorts which serve as food.

The impalpable mud usually corresponds closely in color and general appearance with the bottom in which the mussels are found; in rivers with yellow clay bottoms it is yellowish; in dark, muddy bottoms it is dark. It consists of fine particles which have been held in suspension in the water. In turbid streams it consists of the material which gives the water its turbidity, in clear ponds with bottoms of fine mucky silt it is black, and in those still waters full of diffused minute algæ and flagellates, which are common in ponds and pools, it is predominantly organic and of a greenish cast. In the latter case it usually consists almost entirely of colonies of plankton-scum (water bloom) algæ, which are frequently inclosed in clear vacuolelike spaces.

The moderately long alimentary canal suggests that the ingested material contains a low amount of nutriment; observations also seem to indicate that the digestive powers of the mussel are slow and feeble. In mussels which had been kept for several days *Scenedesmus* was found as fresh and green as ever, and in one mussel obtained in the reservoir of the feeder canal green flagellates were still alive and active after having been at least 36 hours in the mussel. While in these instances it is possible that digestion was delayed by the capture of the mussel and placing in changed surroundings, there are other indi-

cations that digestion is normally slow and imperfect. In mussels taken from the beds, washed, and immediately examined, diatoms found at the posterior end of the alimentary canal are frequently alive and exceedingly active; they appear to be even more active than when taken from open water, and the form and color of the chromatophores are unchanged. It is possible that in these cases the mussel obtains some nutriment from the outer coating of the diatom and that the removal of this makes the latter especially active.

The organisms found in the alimentary canal of mussels vary considerably with the places in which the mussels live, but, so far as observed, do not differ much, if at all, among the various species. They consist of such planktonts as are small enough to be taken in, and not active enough to resist the force of the inward current produced by the mussel. The largest and most active planktont taken to any extent was the entomostracan *Bosminia*. This was found with considerable frequency in lake-dwelling mussels, but as all seen were dead, and many were simply empty shells, it was not possible to ascertain whether the mussel had taken in the living animals or not. Actively moving flagellates are quite frequently ingested. In the gill chamber of some *Quadrula tuberculata*,[a] a species with an exceptionally large inhalent opening, we found such objects as *Chironomus* larvæ and one small mature dipterous insect.

There are several organisms which are likely to be found in mussels wherever taken. Species of *Scenedesmus* are almost invariably present, as is also *Navicula* along with other diatoms and species of *Pediastrum*, such as *P. pertusum* with great frequency, *P. boryanum* rather commonly, and *P. ehrenbergii*, which appears to be a rare species everywhere, only occasionally. The rotifer *Anuræa cochlearis* is also found frequently and under all sorts of conditions, in lakes, ponds, and rivers. The part usually found is the empty lorica. Another common object found in the alimentary tract of mussels is a club-shaped, several-celled, brown object, probably the spore of a fungus or lichen.

With the exception of those just mentioned the organisms found within mussels are very diverse, and the creatures seem to be quite omnivorous within the limits of what they can capture. Just as in any stream one finds various types of plankton aggregates from the extreme type of "potamoplankton" or characteristic river plankton of the mid-current, recognizable by the scarcity of water-bloom algæ, to well-developed types of "limnoplankton" or lake plankton in the quiet sloughs and bayous, so in these different portions of the stream one finds different sets of organisms in the mussels. In lakes full of diffused water-bloom algæ, the material which forms the mudlike matrix of the food in river mussels is to some extent replaced by the

[a] Not in the Maumee River, however, where few were examined.

water-bloom algæ. These may serve also as food. The stomach contents of such mussels, when placed in vials of preservative, differentiate into a lower stratum of black mud and an upper flocculent stratum of fairly pure algæ.

The mussel may be regarded as a sort of living filter, feeding upon the filtrate it separates from the water. It would be worth investigating to ascertain whether they arrest and destroy pathogenic bacteria and thus become efficient purifiers of water. They are valuable aids in plankton investigations, capturing many minute organisms which escape methods of collection ordinarily in use. Though at the outset it hardly looks as if they could cope with the problem, their capacity for ingesting water-bloom algæ (*Clathrocystis*, *Lyngbya*, etc.) suggests that it might be worth while to investigate their efficiency as reducers of plankton scum.

The water bloom, as is well known, frequently becomes a nuisance. It collects in noisome masses of scum along shores of otherwise attractive lakes and reservoirs. Its taste and odor renders the water of reservoirs undrinkable, and for a remedy of this condition the copper sulphate treatment has been devised. Its presence in large quantities along the shores of our most beautiful lakes renders them unattractive during the late summer season, and in many places brings the bathing season to an early close. Aside from the filthy appearance of the water, many persons claim to be actually poisoned by the water bloom, and there are instances on record of live stock being fatally poisoned by drinking water covered with plankton scum. In addition to this, the great amount of decaying material in the water is said to take up oxygen, making the lower strata uninhabitable for fish. It is possible that by planting large numbers of mussels, supplemented by planting egg masses of *Chironomus*, which appear to hatch easily and the larvæ of which eat the coarser algæ, that the plankton-scum nuisance can be greatly abated.

The stomach contents of mussels taken from the main current of the St. Marys, St. Joseph, and Maumee Rivers were rather noteworthy for their paucity of organic material. Through the large mass of muddy matrix filling the stomach were usually scattered a few *Scenedesmus*, various diatoms, and an occasional *Pediastrum* or *Cosmarium*. At the riffles small brown cystlike objects, which may have been a species of *Trachelomonas*, were quite common; with the exception of this the mussel contained very little. Among the organisms noted were *Scenedesmus caudatus*, *Cœlastrum microsporum*, *Pleurosigma*, several forms of *Navicula*, *Phacus longicaudus*, *Pediastrum baryanum*, *Gomphonema*, a sponge spicule, and an active *Euglena*-like organism. The stomach contents of mussels taken elsewhere along the river and in its tributaries, as in the Auglaize at Defiance and the Maumee at Grand Rapids, were not essentially dif-

ferent. One of the examples of *L. ligamentinus* taken in the Auglaize, however, contained many very minute cylindrical objects with rounded ends, which were probably bacteria.

The stomach contents of the mussels found in the reservoir of the feeder canal, a shallow pondlike body of water, bore considerable contrast to that of the river. This reservoir was well populated with small green monads and similar organisms, and during the last days of our observation became covered over with a green scum. It was "puddle plankton" rather than that which is characteristic of either lakes or rivers. The stomach contents of the mussels were greenish in mass, and were found to consist of various organisms, mostly green in color and actively moving.

The main mass consisted of small globular and thick celled, green or brownish flagellates, probably *Trachelemonas lagenella.* Among other organisms were species of *Phacus*, several species of *Scenedesmus*, *Pediastrum pertusum*, *Gomphonema*, several species of *Navicula*, a little *Botryococcus brauni*, *Anuræa cochlearis*, *Cosmarium*, small fragments of a *Conferva*-like alga two or three cells long, fragments of the test of *Ceratium hirundinella*, and the brown objects resembling fungus spores. There were numerous narrow curved objects which were probably loricas of *Trachelemonas.*

PARASITES OF THE MAUMEE MUSSELS.

During the progress of the Maumee River investigations the parasites encountered were noted and examples saved for further study.

Generally speaking, *Anodontas* and other thin-shelled mussels are more heavily parasitized than the species having thick shells, and parasites are more abundant in shallow, warm, and quiet pools than in rivers.

The mussels of the feeder canal reservoir were more heavily parasitized than those of the main streams. The following parasites were observed:

1. *Cotylaspis insignis* Leidy, a small organism, which to the naked eye resembles a pale leech. The body is trumpet shaped, and the ventral surface has a large ovate disk cut up by partitions. By this disk the animal adheres to its host, and it usually inhabits the axils of the inner gills. It was most common in *Anodonta grandis* and occurred occasionally in most other species of mussels examined. An example of *Lampsilis rectus* obtained at the riffles contained the surprisingly large number of 67 of these parasites. So far as could be ascertained, this parasite produces no marked physiological effect upon the host and appears to do no particular harm.

2. *Aspidogaster conchicola* Von Baer bears a close general resemblance to the above, but is considerably larger, and the adhering

disk, which is larger and more complicated, has been aptly compared to the sucking disk of *Remora.*

This parasite affects various species of mussels, but its favorite hosts are species of *Anodonta*, *Symphynota complanata*, and *Lampsilis alatus*, in which considerable numbers were found. It usually inhabits the pericardial cavity of the host, though when considerable numbers are present they may be found in other parts of the body.

The finding of a small elongate " hinge pearl " in a mussel affected by these parasites suggested that, under peculiar circumstances, the body of one of these creatures may form the nucleus of such a pearl, since the shape of the two is quite similar. This supposition, however, needs further investigation. *Aspidogaster* reproduces within the pericardial cavity of the host without any marked metamorphosis, and they are found of all sizes, the minute ones having the same form as the adults.[a]

3. *The marginal-cyst distomid.*—A distomid forming spherical cysts was fairly common, especially in *Lampsilis ligamentinus* and *L. ventricosus*, along the whole length of the river. A few of these parasites were also found in one *Quadrula undulata* and one *Symphynota costata.* It is probably the species discovered and briefly described by H. M. Kelly,[b] who noticed it in four examples of *L. ligamentinus.*

The cysts are usually found along the edge of the mantle, generally in the muscular portion below the pallial line. They are also frequently embedded in other parts of the body, such as the adductor muscles, and especially in the keel of the foot, where they are occasionally found in great numbers. There are indications that they prefer muscular tissue.

Cysts of various ages were frequently present side by side in the same mussels. The youngest cysts are translucent and refractive, faintly yellowish in color, and resemble minute pearls embedded in the edge of the mantle. As they grow older they form conspicuous black dots. One of the smaller cysts measured was 0.3 millimeter in diameter, and a large blackish opaque one was 0.9 millimeter.

Examined with a microscope the younger cysts appear as brick-red spheres, crossed and recrossed by irregular cracks like those of a dried mud flat. Upon carefully breaking open this crust a minute distomid is released, which slowly crawls about on the slide. One of the distomids thus released was colorless, 0.365 millimeter long and 0.21 millimeter wide at its widest portion. Viewed from above, it was pear shaped in outline, the anterior end being acute, the body gradually broadening behind and the posterior end being rounded. It had

[a] The development of this species is given by Huxley, Anatomy of Invertebrate Animals, p. 178.

[b] Bulletin Illinois State Laboratory of Natural History, vol. v, p. 406.

two suckers, an anterior one at the small anterior end and a ventral one, about the same size, placed far back near the swollen posterior end. The posterior part of the distomid contained a mass of black material, probably food.

As the cyst increases in age it becomes black and forms a conspicuous dot about the size of a pinhead in the tissue. It is found on examination that the cyst itself, which is surrounded by the black material, has not increased in size, and the wall retains its brick-red color. The appearances indicate that the black material, which is probably a product of excretion of the parasite, has been passed through the cyst wall.

In our alcoholic material the cysts, which appear as small black spots to the naked eye, show under the simple lens as minute orange globes, surrounded by a semitranslucent halo, the alcohol having apparently dissolved out the black material around the cyst wall.

The marginal-cyst distomid reminds one in its general appearance of *Diplostomum*, which is frequently found encysted in the skin of fishes, especially minnows, forming small black spots. In the fishes, however, the black color surrounding the cyst appears to be due to a deposit of pigment by the fish.

The effect of this parasite (the marginal-cyst distomid) upon the mussel appears to be quite various, according to the location of the cyst. In many cases, probably where the cysts are near the inner surface of the mantle, no effect whatever appears to be produced upon the shell. Under other cysts the shell is stained brown, and where the cysts are near the outer surface of the mantle the whole edge of the shell is blistered irregularly and stained a steel-blue color. Moreover, as the cysts increase in size they form firm nodules in the mantle and cause the shell to be built out around them, so that they leave pits in the nacre similar to those left by pearls.

In studying the collection of shells of *L. ligamentinus* at the Bureau of Fisheries, which contains perhaps 2,000 specimens of this species and is represented by shells from widely separate parts of the country, peculiar malformations of the shell were observed, which were probably caused by the parasite under discussion. Among these markings are pits near the margin of the shell, such as we have frequently observed in the living mussel underneath the cyst, and sometimes these contain small attached pearls. One of the most marked features is a tendency of the antero-ventral portion of the shell to cease growing outwardly and either become thickened or gape away from the middle line so that the mussel can not tightly close its shell in front. It appears that the presence of the cysts keeps the affected portion of the mantle in a constant state of contraction, thus preventing it from building the shell outward in the

normal fashion. In some of our alcoholic material this contraction and thickening of the mantle is quite markedly shown. The effect of this peculiar form of growth on the shell as a whole is to give it a somewhat more inflated and elongate appearance than is characteristic of the species. Shells of *L. ligamentinus* thus affected approach the contour of *L. luteolus*; and while close approximation of these two species is not rare in normal shells, some of the puzzling cases are probably *L. ligamentinus* which has been modified by this distomid.

In *L. ventricosus*, which is very susceptible to the attacks of this parasite, we frequently have gaping shells, and others which are markedly thickened. Some of these thickened shells closely resemble those of *L. ligamentinus*. The marginal-cyst distomid is of especial interest on account of its connection with pearl formation.

Suspicion that this distomid had some connection with the formation of pearls was aroused when the objects were first encountered, as their form and position was especially suggestive. This suspicion was intestified by frequently finding small round pearls in the mantle of mussels, closely associated with the cysts. Finally, on decalcifying and clearing in paraffin and xylol, preparatory to embedding, a portion of the mantle containing a small round free pearl surrounded by the cysts, a cyst could be clearly distinguished in the center of the pearl. Our material, which was preserved by simply dropping the mussels into strong alcohol, was not in good condition for histological purposes, so that we were unable to demonstrate the nature of the tissues surrounding the pearls.

Our studies indicate that the marginal-cyst distomid is widely distributed. We have found the cysts in alcoholic material collected in the Mississippi River, in *L. ligamentinus* collected by Freeland and Williams in the Illinois River in 1907, in *L. ventricosus* collected in the Yellow River, Ind., by ourselves in 1908, and in *L. ligamentinus* collected in the Ohio by Boepple in 1909. From the appearance of shells examined, we judge it to be common in the Minnesota River.

4. *The distomid of Osborn.*—Quite frequently during our mussel investigations we have found *Anodonta* affected with small white sporocysts, which covered the outside surface of the mantle next the nacre. The nacre of these mussels was often raised into a number of sharp pearly blisters, and in some cases small white areas, conforming with the size and shape of the sporocysts, indicate that the sporocysts had been actually covered with nacre. Mussels thus affected were found in the Little River ditch near Aboite Station, Ind., and in White Bear Lake and Lake Minnetonka, near St. Paul, Minn., in 1908. Notes on alcoholic examples of *Anodonta* collected in Wild Cat Creek, Carroll County, Ind., in 1899 refer to "white distomids," which were probably this species.

In the reservoir of the feeder canal at Fort Wayne we found an *Anodonta* plentifully infected with these sporocysts, and were able to make out in detail some of the steps in the life history of the animal.

The sporocysts were small white objects, elliptical in outline, about 1.14 millimeters in length and 0.05 millimeter wide. The skin of the sporocysts was transparent enough to reveal, in the interior, the cercariæ, which were three in number in most cases examined, closely doubled up and snugly packed together, and performing an uneasy wiggling motion. The walls of the sporocyst easily rupture; in an example studied at St. Paul the previous year the covering was torn apart by a dissecting needle and the cercarian set free. In the example now under discussion the sporocysts were rupturing of their own accord, allowing the cercariæ to escape. The following is a description of the various stages observed:

Cercaria just escaped from the sporocyst:

Body elongate cylindrical with bluntly rounded ends and divided by a well-defined constriction into an anterior two-thirds, the body proper, and a posterior one-third, the "tail." Body portion elliptical in outline with the two ends similar. Anterior sucker terminal, about one-fourth the greatest body diameter, circular, with concentric ridges faintly marked.

Posterior sucker one-third body diameter, also circular, but with radiating ridges, situated almost in the exact center longitudinally as well as transversely; constriction only one-seventh the body diameter with a well-defined groove all the way around. Posterior portion (tail) almost perfectly elliptical, twice as long as wide, both ends alike and more bluntly rounded than the body proper. Tail covered with a thick epidermis, raised into longitudinal ridges close together, very narrow and zigzag in arrangement.

The internal structure is indistinct, but far enough developed to distinguish the pharynx and digestive canals. The former is relatively smaller than in the adult and is much nearer the posterior sucker than the anterior one. This means that in after development the posterior sucker travels backward, while the pharynx travels forward. At this stage the whole interior of the body is filled with large cells having numerous and interlacing intercellular spaces.

After remaining under the cover glass for a little time the tails break off at the constriction and the body moves about alone.

The following is a description after the tail is shed:

Body elongate, ovate, without any traces of segmentation or separation into parts; anterior end evenly rounded, posterior end drawn out into a point, bluntly rounded at the tip.

Anterior sucker terminal, circular, three-sevenths the diameter of the body, with circular ridges. Posterior sucker on the mid line

of the ventral surface, four-sevenths of the entire length from the anterior end, circular, with radiating ridges and four-sevenths the diameter of the body. Posterior end of body with traces of the zigzag longitudinal ridges seen on the tail of the young. Mouth in the center of the anterior sucker, opening into a spherical or transversely elliptical pharynx close behind the sucker and one-third its diameter. From the pharynx two digestive tubes lead back to the posterior end of the body, one on each side, each a little narrower than the pharynx, of nearly uniform diameter throughout, and curved outward parallel to the lateral body margin. They reach nearly to the posterior end of the body, where each ends in a network of intercellular spaces and tubes, the excretory organ.

The newly escaped cercarium is about 1.05 millimeters in total length and 0.2 millimeter wide. The length and width are constantly changing, according as the organism is stretched out or contracted.

The tail is no longer an organ of locomotion; it is very large and unwieldy and easily detached; most of the cercaria shed it soon after emergence from the sporocyst, so that it is evidently a vestigial organ.

After shedding the tail the organism, which now has the typical form of a *Distomum*, moves up to the umbonal region of the mussel and acquires a pinkish color. From the umbones it spreads in diverging lines postero-ventrally and antero-ventrally and finally fills in the space between. Where it is located it profoundly affects the nacre, staining it a salmon color, and frequently giving it a diseased appearance. The presence of this distomid in *Anodonta* and its relation to the salmon-colored nacre was first pointed out by H. L. Osborn[a] and further discussed by H. M. Kelly.[b]

In its general appearance and in its life history this organism agrees very closely with *Distomum duplicatum* as described by von Baer, who gives a detailed description of the sporocyst and a history of the escape of the cercaria and its subsequent behavior.[c] It differs from that species in the fact that the tail is not clavate, is longer than the body, straight, and not pediculate. It differs from the cercarian genus *Rhophalocerca* Diesing, formed to include *D. duplicatum*, only in the fact that the tail is not clavate. Von Baer describes what appeared to him a form of reproduction in this distomid, but from what is now known of related forms it appears probable that he misinterpreted appearances. *Distomum duplicatum* (known also as *Rhophalocerca tardigrada* Diesing) is of special interest as the organism first shown by De Filippi to be the cause of pearls in

[a] Zoological Bulletin, vol. I, no. 6, 1898.

[b] Bulletin Illinois State Laboratory Natural History, vol. V, art. VIII.

[c] Nova Acta Physico-Medica Academiæ Cæsareæ Leopoldino-Carolinæ, Natural Curiosorum, vol. XIII, pt. 2, 1827.

Anodonta cygnea of Europe; hence a few remarks concerning it may not be out of place.

So far *D. duplicatum* has not been reported from any mussels except *Anodonta.* Its discoverer found it usually in the kidneys of *Anodonta ventricosa* and more rarely in the same organs in *A. anatina.* One badly infected example of this latter species had the sporocysts in the kidneys, gills, pericardial cavity, and edge of the mantle, and in an example of *A. ventricosa* they were even present in the general circulation. Filippi found the sporocysts and free distomids in the mantle of *A. cygnea*, some of them surrounded by nacre; and Pagenstecher found them in the tissue of the genital glands, liver, and kidneys of the same species. In this country Leidy[a] has reported "*Rhophalocerca tardigrada* attached to the mantle of *Anodonta fluviatilis;* specimens also obtained by Mr. Lea from *A. lacustris.*"

The mature form of *Distomum duplicatum* is said to be *D. tereticolle* Rudolphi, a parasite of fresh-water fishes.

To return to the distomid of Osborn: In addition to its being found in *Anodonta grandis*, this parasite (in the distomid form) has also been reported from *Strophitus edentulus* by Osborn. We had very few living mussels of this species to examine; however, we found dead shells with the peculiar salmon-colored nacre, similar to that produced by this parasite in *Anodonta.*

In view of the fact that a *Distomum* quite similar in appearance to this is found in other species of mussels, while sporocysts are rare (we found them only in the liver tissue of one example of *Quadrula tuberculata* in Tippecanoe River), it becomes an interesting question whether this distomid migrates from the *Anodonta* to other mussels after issuing from the sporocyst. In the first place, such a migration is probably not an event closely connected with the life history of the species; for the tail, which functions as an organ of locomotion in those species which do migrate, has here been allowed to become functionless, or even a dead weight. Moreover, if the host of the mature form is a fish, as one might expect it to be from the life history of its near relative *D. duplicatum*, it would be to the advantage of the distomid to remain in the thin-shelled *Anodonta*, which is much more likely to fall a prey to fishes, or indeed any other predaceous animal, than the thicker-shelled species of mussels. It is very likely, however, that, just as in greatly infested mussels the cercariæ frequently overflow the organs which appear to be their favorite habitat, so a considerable number of distomids may be crowded out of the host mussel and be forced to seek protection and food elsewhere. According to von Baer[b] the sporocysts of *Distomum*

[a] Proceedings of the Academy Natural Sciences, Philadelphia, 1858, p. 110.
[b] Loc. cit.

duplicatum and their contained cercariæ live for a considerable time in the water when removed from the host. Migration would therefore be possible.

It has so happened that the *Anodontas* in which we found sporocysts were all taken in early and middle summer, in July or August; we found free distomids, however, as early as work in the field began, in June. It would require the study of infected regions throughout the year to ascertain whether the various phases in the life cycle of this distomid bear any relation to the seasons. Von Baer found his *Anodontas* affected by the sporocysts of *D. duplicatum* in late autumn.

5. *The distomid of Kelly.*—In several of the thicker-shelled species of mussels, such as *Lampsilis ventricosus*, *L. ligamentinus*, *Obovaria circulus*, and especially in *Quadrula tuberculata* and *Unio gibbosus*, one frequently encounters pink distomids bearing a close similarity to the distomid of Osborn mentioned above. Kelley,[a] who first described and discussed these distomids, was of the opinion that they are identical with those described by Osborn as affecting *Anodonta* and *Strophitus* and producing a discoloration of the nacre.

Indications pointing to the identity of these two distomids are, first, the fact that dorsal baroques are formed in *Anodonta* by the distomid of Osborn, and second, that the distomid of Kelly, in addition to forming baroques in *Obovaria circulus*, frequently causes the nacre to become rough and assume a yellowish color, approximating the salmon color of affected *Anodontas.*

In their typical form as they appear in the thick-shelled species of mussels, these distomids exhibit several minor points of difference from the distomid of Osborn. Practically they present so different a set of manifestations that in our field notes it was found necessary to separate them.

After considerable study and comparison we are inclined to think them the same, but in this discussion, since the point of view is ecological rather than taxonomic, it will conduce to clearness to refer to this manifestation of the species under a different name. Similarly, it is convenient and customary to speak of the cercaria of a distomid, the nauplius of a crustacean or the leptocephalus of an eel. The distomid of Kelly is usually found in much fewer numbers than that of Osborn, a fact which suggests that it may be erratic or a stray migrant, and so far we have not found it associated with sporocysts or cercariæ except in the single instance of *Quadrula tuberculata* referred to above. It is usually confined to the outer surface of the mantle near the cardinal or lateral teeth of the mussels affected, and it is frequently associated, as Kelly has pointed out, with irregular dorsal baroques or pearls. It does not produce a salmon-colored stain in the nacre of the mussel affected, and usually

[a] Bulletin Illinois State Laboratory Natural History, vol. v, art. 8.

produces no stain at all. The discolorations frequently found in the umbones of mussel shells can not all be attributed to it, since in one pond where such stains are very frequent, no distomids could be found. In general, it is a baroque former rather than a stain producer. In some localities it especially attacks *Unio gibbosus* and *Quadrula tuberculata*, and the host mussels are peculiarly prolific in baroques. Most of the dorsal baroques which the clammers save and sell to dealers in jewelry are probably formed through the activities of this parasite. The baroques are known among the clammers as " chicken feed " and usually bring about $2 per ounce on the ground. In many places this material is fairly common and is a source of revenue among the clammers.

It is probable that the distomids which stray into large heavy-shelled mollusks fall out of the normal course of their life history unless they again migrate to thinner-shelled species, for the thick-shelled mussels, after they have grown, are proof against fishes, musk-rats, or any other predaceous animals, and live to die a natural death, or in these recent times to fall a prey to the clammer. This gives the parasitic distomid no opportunity to enter into another host in the usual manner. Crawfishes eat mussels that have died; but so far as known the host of the mature distomid is always a vertebrate.

Moreover, on the supposition that the distomids found in the heavy-shelled mollusks are migrants from *Anodonta*, *Strophitus*, or other thin-shelled species, these mussels, which are regarded as valueless by the clammer and destroyed by the wholesale, are of importance as an intermediary in the formation of baroques and perhaps all distomid-formed pearls. Similarly, though in a somewhat different manner, the cockle, *Cardium*, acting as an intermediate host between a species of mussel-eating duck and the salt-water mussel *Mytilus*, brings about pearl formation in the latter species, as shown in the investigations by Jameson [a] of pearl formation in *Mytilus*.

6. *Bucephalus polymorphus* (von Baer).—During the Maumee investigations this species was encountered in only one instance, when an example of *Lampsilis luteolus*, obtained near the mouth of the St. Joseph River, was found to be affected. In investigations outside the Maumee Basin it was not infrequently met. According to Kelly, who has had considerable experience with mussel parasites, it is fairly common, though not so common as *Aspidogaster*, *Atax*, or *Conchopthirus*, and affects a large number of species of mussels.

Bucephalus polymorphus is of considerable economic significance, since it has been shown by von Baer and later by Kelly that this species (and, as Kelly has pointed out, some other distomids as well) frequently affects the generative tissue of the host mussel to such an

[a] Proceedings Zoological Society London, vol. I, 1902, pt. 2, p. 140–166.

extent as to wholly obliterate it and render the mussel incapable of reproduction. In those mussels (*Lampsilis gracilis*, *L. luteolus*, etc.) in which there is a marked difference in the form of the shell of the two sexes, *Bucephalus*, by arresting sexual development at various periods of the mussel's life, stops also the development of the peculiar form of shell characteristic of the sex. Shells are thus left at various intermediate stages of sexual development, though they may attain full size, and this has doubtless led to considerable perplexity in identifying them, or even to the descriptions of new species. It may also be partly responsible for the large amount of synonymy found in the *Lampsilis ventricosus* group.

It can be readily inferred that the introduction of *Bucephalus*-infected mussels into places where breeding or breeding experiments are being carried on would be likely to produce disastrous results. In collecting mussels for propagating purposes, therefore, shells of indifferent contour as regards sexual peculiarities should be viewed with suspicion. In addition, examples should be dissected to detect signs of the presence or absence of the trematode.

The mature form of *Bucephalus polymorphus* is *Gasterostomum fimbriatum* von Siebold, which is a parasite of the pike (*Esox*) and perch (*Perca*), and an intermediate host (eaten by the final host) is some species of minnow. (*Leuciscus* is one of the known hosts.) In ponds devoted to the breeding of mussels the ravages of *Bucephalus* might be held in check by avoiding the peculiar combination of mussel, minnow, and pike or perch, provided of course these were not the particular species of fishes required to carry the glochidia.

7. *Ascaris*-like worms were occasionally found in the alimentary canals of mussels, and are probably to be regarded as parasites.

8. Leeches were found quite frequently on the inside of the shells of *Anodonta*, in all probability genuine parasites. They appear to be quite fond of the mucus of mussels, as is shown by the following observation: On the inside of a number of valves cleaned by muskrats and left on the bottom in Lake Maxinkuckee, the leeches were found to have accumulated in considerable numbers. Leeches also frequently attack other species of mollusks, as *Planorbis*, in large numbers. It could not be ascertained whether they injured the mussels to any marked extent or not.

9. *Atax ypsilophorus* was a common parasite of mussels throughout the length of the river, and was particularly common on *Anodonta* in the reservoir of the feeder canal. An example of *Atax*, probably this species, found in a mussel at the riffles of the St. Marys River, was so heavily burdened with a growth of *Vorticella* on its body that it could hardly move about. We came across several other specimens similarly affected.

Atax intermedius and *Atax tumidus* were also common on the mussels in the reservoir. There were probably several other species of *Atax* present; a small species with a red spot posteriorly was quite common. *Lampsilis alatus* below the dam at Grand Rapids was particularly heavily infected; in three examples 290 mites were found, thus averaging about 97 per individual.

Many of the *Atax* were full of eggs, and eggs and larvæ in different stages of development were common but not markedly abundant on the inner side of the mantle and in the gills of the mussels. We did not observe this year what was so conspicuous a feature in 1907 of the mussels found in the lakes about St. Paul, Minn., at the same season of the year, viz, the young mites clustered thickly about the papillæ of the inhalent siphons. The mites were apparently not breeding as heavily in the Maumee, and the young were not so far advanced in development at the date examined. *Atax* probably produces considerable irritation in the mussel, but we have no evidence that it affects shell characters. Where they bury their eggs in the tissue of the mussel they leave small but conspicuous scars which are apparently permanent.

Although it has been suggested that the eggs of *Atax* may lead to the formation of pearls, we have been unable so far to find convincing evidence on this point. In our studies of mussels of the Wabash Basin we obtained a great number of calcosphæric structures, many of them in situations that suggest a close relation to *Atax* eggs. This subject is reserved for future investigation, as it does not pertain to Maumee studies and would lead too far afield.

Wherever we have examined mussels we have encountered the parasite *Conchopthirus*, a protozoan bearing considerable superficial resemblance to *Paramœcium*. This organism is of such universal occurrence that we have not taken trouble to specifically mention its presence. There are several species (*curtus*, *anodontæ*, etc.) parasitic on fresh-water mussels.

GENERAL CONCLUSIONS.

The Maumee River, as it exists to-day, is not on the whole a stream where clamming operations could be carried on profitably, as it would very quickly become exhausted if such operations were undertaken on a large scale. The mussels were apparently once much more numerous than at present. There are two conditions which militate against the well-being of mussels in the upper part of the river: The large amount of sewage, especially refuse from the gas works, and the irregularity of flow of the river, which has been increased by the removal of much of the original forest along the river banks. The best mussel beds in the river are at Fort Wayne, Ind., and below the dam at Defiance, Ohio. By far the greater number

of marketable shells in the river are *Lampsilis ligamentinus*, and the most valuable native species is *L. rectus*.

The species of mussels to be recommended for propagation naturally varies with different rivers. In the Maumee, the species generally regarded as the best button shell, the niggerhead, *Quadrula ebena*, could not be recommended as it is doubtful whether it would thrive in the shallow water. On the other hand, the mucket, *Lampsilis ligamentinus*, in many waters a poor or indifferent shell, is here remarkably large and thick, with nacre of an excellent luster, and is the best button species found in the river. This should be planted extensively as the main crop. *Plagiola securis*, the butterfly, would probably thrive in the water below Defiance Dam, and *Symphynota costata* would be well worth trying, especially in canals with black muddy bottoms, as it would be nearly certain to attain to unusual size and thickness there, and might rank as a good button shell.

The status of *L. rectus* is peculiar. In many streams and rivers this species is valueless on account of small size or purple nacre or both; in the Maumee it has large size and white nacre and is the most valuable species per pound native to the river. With enough button shells in the river to bring this species to the market it would be desirable to plant rather heavily of it. It would make a good export shell and yield the clammer much more revenue for work done and material handled than the button species.

The most valuable of the fresh-water mussels, *Lampsilis anodontoides*, would be well worth a trial. It is not native to the river, but there is every reason to believe that, like its close relative *L. rectus*, it would grow and thrive considerably better even than in rivers where it is native. Good shells of this species bring an unusually high price on the market.

As regards mussel parasites, the river appears to have about the average number as compared with other streams examined. They are usually most abundant in thin-shelled species in quiet waters. As regards pearls and pearly growths, which are closely related to parasites, these are few. The distomid of Kelly and dorsal baroques are rare. Round pearls, all very small, were occasionally found, and all these appear to owe their origin to the marginal-cyst distomid, which is quite common.[a]

[a] Since this was written, we have found several minute pearls which were formed about eggs of *Atax*.

THE MUSSEL FAUNA OF THE KANKAKEE BASIN

By CHARLES B. WILSON and H. WALTON CLARK

Bureau of Fisheries Document No. 758

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FIG. 2.—A DREDGED PORTION OF THE KANKAKEE RIVER. ALL THE MUSSELS HERE WERE KILLED BY DREDGING, AND NOT ONE CAN LIVE UNDER THE ARTIFICIAL CONDITIONS HERE ESTABLISHED.

THE MUSSEL FAUNA OF THE KANKAKEE BASIN.

By Charles B. Wilson and H. Walton Clark.

INTRODUCTION.

The following paper gives the results of fresh-water mussel investigations made by the authors in the Kankakee Basin during the summer of 1909, under the auspices of the United States Bureau of Fisheries.

The mussel fauna of the various localities is recorded in the table on page 38, and forms an important result of the investigations. But careful attention was also given at each of the localities to the kind of bottom on which the mussels were found, the depth of water and rapidity of the current, the relative temperature of the water, the nature of the plankton present and suitable for food, the actual stomach contents of selected samples, the relative size and physical condition of the mussels, the small fish and crawfish found on or near the mussel beds, and the times of spawning of the various mussel species. In particular, most of the species secured alive were examined for parasites, for the color of the nacre and any staining or spotting produced by the parasites, and for pearls or baroques as a result of parasitic infection. The results of these studies are given under the various stations where they were made and constitute by far the most valuable portion of the work.

Samples of the shells were afterwards examined by Mr. J. F. Boepple and others who are experts in the manufacture of pearl buttons. The value per ton of the different marketable species was carefully estimated and is recorded in the table on page 39, giving some idea of the economic importance of the investigation.

The boat was put into the Yellow River at Burr Oak, Ind., and traversed the remainder of that river to its junction with the Kankakee, and the latter river from this junction to the city of Kankakee, Ill.

The river below this city, the upper portions of both the Yellow and Kankakee Rivers, the whole of the Iroquois River, and the various lakes and tributaries, were worked by means of short drives

from the nearest railroad towns. At each of the lakes a boat was secured and the whole of the lake shore and as much of the outlet as was deemed advisable were examined. The fact that quite a portion of the Yellow and Kankakee Rivers has been artificially dredged and the old winding channel converted into a straight cross-country ditch, presented changed conditions of extreme importance in their relation to mussel propagation. These conditions have been accurately recorded, and furnish an instructive contrast to the remainder of the area worked.

While the entire Kankakee Basin was thus more or less completely examined and satisfactory results were obtained, the authors would not regard the work as in any sense final. It is rather initiatory and suggestive, and its value lies in the data and comparisons it furnishes with reference to the natural conditions under which mussels live and thrive in a region which has been as yet scarcely touched by the progress of civilization.

PHYSICAL FEATURES OF THE KANKAKEE BASIN.

The Kankakee Basin embraces the whole of the northwest corner of the State of Indiana south of the narrow Great Lakes drainage, and adjacent portions of Illinois, and is drained by the Kankakee, Yellow, and Iroquois Rivers and their tributaries. These 3 rivers, the principal streams that flow into them, and 12 of the more important lakes lying within the basin were thoroughly examined.

This basin is radically different from that of the Maumee River, previously examined, in that the Indiana portion of it lies wholly within what geologists designate as a plain of accumulation. The origin of the valley can not be stated more concisely than in the words of W. S. Blatchley in the Twenty-second Report of the Geology of Indiana, page 59:

> The valley doubtless owes its origin to the flow of waters which followed the melting of one of the later retreating ice sheets. This flow was at first sufficient in volume and velocity to erode the present valley to quite a depth through the underlying clay. Later, on account of a diminution of the supply of water, as well as the gentleness of the slope, the current became too sluggish to erode much deeper or to carry coarse material, and only the finer sediment was brought down. From a still further diminution of the water supply, as well as by the building up of a sedimentary dam near the western end of the valley, the water for a long period ceased to flow, and a lake of shallow depth resulted. Again by a new accession of water from the northwest, the barrier at the foot of the valley was washed away and the river of the present had its beginning. At first its waters flowed the full width of the valley, but in time their volume decreased, and a portion of the river's bed became bare in summer. Over this a vegetation sprang up and decayed. A soil was thus started above the sands and was added to each year by the decay of the summer's vegetation and the sediment brought down by the overflow in the spring. The main current of the stream was thus gradually narrowed until it reached its present size.

We thus have a basin surrounded by glacial moraines and everywhere covered with a heavy mantle of glacial drift or till, so thick that not a single outcrop of surface rocks is known to occur within its limits,[a] even in the bed of the river or any of its tributaries. Consequently, there are no rocky bottoms with alternating riffles and quiet reaches, but everywhere a uniform current and labyrinthine windings. The river itself is noted for its low banks and the crookedness of its channel. It rises in a marsh about 3 miles southwest of South Bend in St. Joseph County, Ind., flows southwesterly through that county to the Laporte County line, from which point it forms the boundary between the counties of Laporte, Porter, and Lake on the north, and St. Joseph, Starke, Jasper, and Newton on the south. At about the center of the Starke County line it receives the Yellow River as a tributary from the east. Crossing the State line between Lake and Newton Counties, it flows south of west to the town of Waldron, Ill., where it is joined by the Iroquois River from the south. Thence it flows northwesterly to the northeastern corner of Grundy County, where it joins the Des Plaines, coming from the north, and the two form the Illinois River.

The Yellow River, its principal eastern tributary, rises in three forks, north, middle, and south, in the southeastern corner of St. Joseph County, Ind., the southwestern corner of Elkhart County, and the northwestern corner of Kosciuszko County, respectively.

The north and middle forks unite near Bremen in Marshall County, and flow directly south until opposite Plymouth, the county seat. Here they are joined by the south fork, and the river turns westward through Plymouth, then south for about 5 miles, and then westward again through the remainder of Marshall and the whole of Starke County, entering the Kankakee at about the center of what was formerly English Lake.

The Iroquois River, the only other tributary of any size, arises in several creeks in the southeastern portion of Jasper County, Ind., flows a little south of west across Jasper and Newton Counties, cutting the State line 6 miles north of the southern boundary of Newton County. It then flows west through Iroquois County, Ill., as far as Watseka, the county seat, where it receives Sugar Creek from the south. The two then flow northwest about 5 miles to a junction with Spring Creek, also from the south. There the river turns almost due north and crosses the remainder of Iroquois County and into Kankakee County, where it empties into the Kankakee River a mile west of the town of Waldron. The Yellow River is about 65 miles, the Iroquois 100 miles, and the Kankakee 300 miles in length. The banks of the Yellow and Iroquois Rivers, and those of the Kankakee River in Illinois, are high and solid and in many places well wooded, and the adjacent country is of the usual prairie type.

[a] That is, in the State of Indiana.

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In Indiana, however, the entire basin of the Kankakee River is marshland, the most extensive body of swamps within the State. On the immediate border of the river there is a strip, from a few rods to a mile or more in width, which is heavily timbered. Then come dense thickets of underbrush, and finally the open marsh, covered with a rank growth of grasses, sedges, reeds, and semi-aquatic vegetation.

There were formerly more than half a million acres of this marshland in the seven Indiana counties drained by the Kankakee, but its area has been recently somewhat reduced by extensive ditching. Enough still remains, however, of this old glacial lake bed to act in the manner of an immense sponge, overflowing and absorbing water during the wet season and slowly oozing it forth during the dry.

There is thus never any real lack of water in the river, the amount of discharge at the State line being considerably over a thousand cubic feet per second even at low water. In general the soil of the marshes is a dark sandy loam, very rich in organic matter, and hence the waters of the river contain an abundance of food material for the mussels they contain. In many places the wild rice, rushes, lily pads, and aquatic grasses fill all except the very channel of the river and contribute their quota of food material. Owing to the fact that the land can not be cultivated, there are few dwellings on or near the river, and repeatedly one may row 15 or 20 miles without seeing a human habitation. The presence of the rich marshes, combined with the absence of human environment, have made this region an ideal breeding ground for waterfowl and aquatic animals of every sort. Fish are also abundant in the river, together with plankton of great variety and richness. Each and all of these conditions have a very important bearing upon mussel life.

And withal the region is one of marvelous beauty and attractiveness, and as radically different in many respects from an ordinary swamp as could well be imagined. In the first place, the river itself, in spite of its intricate windings and rich vegetation, is not sluggish as one would expect, but has everywhere a good current, averaging 3 or 4 miles an hour. Then the river bed is nowhere of the proverbial quagmire type, but is hard sand or fine gravel, mixed with mud to just the right consistency for most mussels. Here, then, we have a region especially favorable in almost every particular for mussel growth, strictly secluded by its environment from all but the hunter, the trapper, and the fisherman, and still maintaining primitive conditions throughout most of its extent. Futhermore, its waters have always drained into the Mississippi Basin as they do now, and the mussel fauna, originally derived from that source, has never undergone any radical changes.

We may be reasonably certain, therefore, that the data here obtained are natural and authentic, and that they have not been to any degree artificially modified.

MUSSEL SURVEY.

LOCALITIES EXAMINED.

Station 1. The middle fork of the Yellow River.—The entire upper portion of this river, down to within 6 miles of Plymouth, has been recently dredged. The result has been a conversion of the winding forks of the river and their tributary streams into a series of straight cross-country ditches, in which the water flows at a uniform rate over an equally uniform and undifferentiated bottom of sandy gravel.

These ditches were examined at several places (the first four stations) in order to ascertain what effect the dredging had upon the mussels and other life in the headwaters of the river. The dredged material, thrown up along the sides of the ditches, everywhere presented abundant evidence that mussels were formerly present in considerable numbers. But the process of dredging, by throwing out the living mollusks upon the land where the ditch coincided with the old channel and by withdrawing the water from such portions of the old channel as did not thus coincide, *completely destroyed the entire mussel fauna.* There has been some restocking of the new channels by ordinary natural methods, but the conditions have been extremely unfavorable for such restoration. Our fresh-water Unionidæ are dependent upon small fish for their distribution and for transportation into new regions like those created by this dredging. At the last rebuilding of the dam at Plymouth no fishway was provided. Consequently, the only fish available, as well as the only supply of glochidia, had to come from the short undredged space of 6 miles above the Plymouth dam and from such specimens as may have escaped destruction during the dredging. Furthermore, the reduction of the water channels to an absolutely uniform grade and depth has proved very unfavorable to the spread of mussel life. The constant shifting of the sand and soil along the bottom of the channel effectually prevents the young mussels from obtaining a stable foothold anywhere. In the presence of such adverse conditions it was remarkable to find any evidence of a restoration of the mussel fauna.

This first station was near the town of Bremen, in the northeastern corner of Marshall County; the ditch representing the middle fork of Yellow River was 6 feet wide and the water was about 8 inches deep at the center. There was no vegetation of any sort present, and no fish or crawfish could be found for the distance of a mile above the town. The bottom of the ditch was gravel or sand, kept

in constant motion by the swift current. The only trace of mussels were the dead shells which had been dredged out of the old channel and left high and dry along the sides of the ditch.

Station 2. Half a mile below (west of) Bremen.—The ditch had been enlarged here to 10 feet in width, and the water was knee-deep (22 inches) at the center, with a current fully 8 miles an hour. The bottom was of sand over firm peat, and there was some vegetation in the form of scattered patches of *Ceratophyllum*. This served to prevent in places the constant motion of sediment along the bottom and gave an opportunity for mussels to establish themselves. The three specimens recorded were found alive and of fair size, and there were more of the dead shells in the piles of clay along the banks than at the previous station.

A number of *Campeloma*, *Sphærium*, *Planorbis*, and *Pisidium* shells were also found, which probably represented the inhabitants of a swale that had been drained by the ditch. No fish or crawfish were seen. The only mussels found were two "fat muckets" (*Lampsilis luteolus*) and one "floater" (*Anodonta grandis*).

Station 3. Junction of north and middle forks.—This junction is about 2 miles west of Bremen and a few rods north of the Baltimore & Ohio Railroad tracks. The north fork is much the larger and its waters were very muddy, in strong contrast to those of the middle fork.

No life at all, animal or vegetable, except a few young pike, *Lucius reticulatus*, was found at this station. This was probably due to the fact that the peat over a large area along both sides of the forks and the main stream had been recently burned to a considerable depth, changing the water, for the time being, into a sort of lye.

Station 4. Yellow River, 1 mile below station 3.—The ditch here is 12 to 15 feet in width, and the water is 2 to 3 feet deep at the center; the bottom is gravel and clay, firm and solid, with a slower current, about 6 miles an hour. The ditch has been cut through about 8 feet of blackish alluvial soil, and the water, in consequence, is turbid.

There was no vegetation in the water, but we found a large number of mature crawfishes, *Cambarus propinquus*, and a few small fishes which proved to be young pike. No mussels were found alive, but there was an abundance of dead shells along the sides of the ditch.

A short distance to the west of this station are two other dredged ditches, running approximately parallel with the river. These are known as the Bunch ditches and were dredged several years before the river itself. They run into Bunch Creek, the first outlet of the Lake of the Woods, and this creek empties into Yellow River 2 miles farther south. Both ditches and the creek were examined for con-

siderable distances, but although fishes and crawfish appeared to be abundant no live mussels could be found. The water in the eastern ditch was quite black and there was considerable "ditch moss" (*Philotria*) in scattered patches. A few small minnows, *Notropis whipplii*, were found here, and a number of sunfish, *Eupomotis gibbosus*, were nesting in the crannies of a pile of rocks that had been thrown into the edge of the ditch from the railroad. The western ditch is shallower and cleaner; the water is yellow instead of black, and quite clear. The bottom is a fine gravelly clay, well adapted for mussel life, and many *Cambarus propinquus* were seen.

These facts seem to indicate that even after the conditions become again favorable for mussels it still takes a long time to restore them under natural conditions. In all probability the introduction of small fish well infected with glochidia would materially hasten the restoration of the mussel fauna here.

Station A. The Lake of the Woods.—This lake is situated in the northeastern corner of Marshall County, 4 miles southwest of Bremen. It is 1½ miles long and 1¼ miles in extreme breadth; it is oval in shape, with a fairly regular outline, except on the western shore, where a broad bay increases the width by half a mile. It formerly occupied a much larger area than at present, as is evidenced by the distance from the present water's edge of an old shore line, separated by a broad, sandy, level plain, once lake bottom. On the eastern side large peat deposits extend north into St. Joseph County and south to the line between North and Center Townships. This latter southeast corner was the original outlet of the lake into the Yellow River.

Through the drying up of the lake its area was diminished to one-tenth of the original size. This reduced lake was bordered by high and heavily wooded banks, except at the northeast and southeast corners, and must have been a beautiful sheet of water, plentifully supplied with all sorts of life, including mussels. But a ditch was dug 50 or 60 years ago from the northeast corner into the north fork of the Yellow River and the lake level was reduced 4 feet. The original shore, in places a high, picturesque, abrupt bank, covered with large oak and cottonwoods, can still be seen from 500 to 1,000 feet back from the present beach.

Even this outlet, however, did not satisfy the farmers in the vicinity and another ditch was dug 15 or 20 years ago from the southwest corner of the lake, running south for a mile or more, then turning east into the Yellow River. This lowered the lake again from 2½ to 3 feet and the second lake shore is also visible in many places, covered with poplars and yellow birches.

By these two lowerings the lake has become little more than a mud hole, fringed with reeds and rushes which grow far out into the

water. In addition the bottom of the lake, wherever it can be seen, is entirely covered with plants, *Chara* and *Potamogeton*. In following around the entire lake margin only a single spot was found free from this vegetation. Finally the water itself is filled with a suspended plankton which is entirely vegetative, made up mostly of minute algæ (*Clathrocystis* and *Lyngbya*).

All the water plants are covered with a fuzzy growth of *Mesocarpus*, which also forms in floating masses, and with the *Clathrocystis* collected in large curdlike lumps. Such a lake does not afford good conditions for either fish or mussels and both were very scarce. A careful examination of the entire margin of the lake yielded only 7 specimens of the "fat mucket" (*Lampsilis luteolus*), of which 5 were dead, 16 specimens of *Anodonta grandis*, 14 of which were dead, and 1 dead *Anodontoides ferussacianus subcylindraceus*. As it was of interest to know the food and parasites of mussels living under such conditions, the four live specimens were examined, with the following results: In *A. grandis*, *Atax* was abundant, with an occasional *Cotylaspis*. The distomid of Osborn [1] was exceptionally abundant and made the nacre very rough, but gave a dark discoloration instead of the usual salmon tint. The stomachs yielded *Clathrocystis* and *Cœlospherium* in abundance with some *Pediastrum*. In *L. luteolus* both marginal cysts and the distomid of Kelly were fairly abundant, with no other parasites. Small pearls were found in the margin of one mantle and a small dorsal baroque in the other specimen. The stomachs were filled with *Clathrocystis* and *Cosmarium* well fused into a dark gritty mass.

Station 5. Above the dam at Plymouth.—This dam was built 60 years ago, but has been washed out and rebuilt several times, the last time without any fishway. It backs the water up the river about 4 miles; this dead water and the river for 2 miles above were thoroughly examined, as well as the side lagoons, which are common along the dead water. The center of the dead water was too deep for wading and there were so many snags it was impossible to dredge it. Elsewhere the mussels were widely scattered and not many were found alive. In some places the banks were too soft and miry, in others too hard and solid for mussels, and it was only the infrequent spots between the two that yielded any returns.

On examining the mussels for parasites the following were found: In *L. luteolus* there were many cysts along the mantle margin and the distomid of Kelly was fairly abundant. In many of the specimens there were small pearls and in some of them dorsal baroques. In *A. grandis*, *Atax* was the most common parasite, with a few

[1] This name is applied to a distomid which was found by Prof. Osborn to be the cause of salmon discoloration in *Anodonta grandis;* investigations undertaken since the above was written lead to the belief that the distomid in question, which produces a chocolate instead of a salmon-colored stain, is of a different species.

Cotylaspis. The distomid of Osborn was abundant, producing a dark discoloration and rough nacre like that found at the Lake of the Woods.

Station 6. Below the dam at Plymouth.—This station offered a pleasing contrast to the preceding. The water was shallow, the maximum depth being 2 feet, the bottom was firm sand and gravel, and the current was about 3 or 4 miles an hour. From the dam to the mill race we found good collecting; below there the river became deeper and there were not as many mussels.

Of the specimens obtained one small *L. ventricosus* had a very thin shell with pink nacre; *A. imbecillis* was quite common and five were obtained that were gravid; one *L. parvus* was also found gravid; a few *L. iris* and large *A. calceola* were found along the shore.

In addition to the mussels collected by the authors here, Mr. Aaron Greenwaldt, who had collected shells from the river for the State Geological Survey, presented the Bureau of Fisheries a beautiful collection of 125 shells very perfectly cleaned and kept with the two valves tied together. For this valuable present the authors here return sincere thanks. The collection included the following species, the number of specimens being given after each: *Q. coccinea*, 16; *Q. rubiginosa*, 6; *Q. pustulosa*, 3; *Q. undulata* (from above the dam), 6; *S. costata*, 12; *S. compressa*, 7; *A. imbecillis*, 1; *S. edentulus*, 2; *A. grandis*, 10; *L. iris*, 6; *L. luteolus*, 20; *L. ventricosus*, 21; *U. gibbosus*, 15.

Of the small fishes obtained at this station the straw-colored minnow (*Notropis blennius*), chub (*Semotilus atromaculatus*), and Johnny darter (*Boleosoma nigrum*) were particularly abundant and many of each species were put back into the river. A considerable number of the young straw bass (*Micropterus salmoides*) and grass pike (*Esox vermiculatus*) were also caught, but only one or two samples were kept. We were told there was a severe attack of the "pearl fever" here during the previous year and that the boys brought out and examined mussels by the barrel without material results. If so, they must have disposed of the shells, since none were found except a single pile, containing about a ton and a half, a short distance below the dam.

Station B. Pretty Lake.—Pretty Lake, situated 3 miles southwest of Plymouth, is a typical glacial kettle hole, nearly circular in outline and about half a mile in diameter. The water is remarkably clear and has a fine greenish tint, like that of Lake Maxinkuckee.

It is fed by springs, the entire northeastern shore being covered with them, and at present has no outlet. There is a single inlet at the northwest corner which is a dry run most of the time, but the presence of a large gravel delta testifies that at times it discharges

considerable water into the lake. There is an old outlet at the southeast corner of the lake, which formerly drained into the Yellow River. Although the mouth is closed by a sand bar, the water in the lake occasionally rises high enough to overflow this and run into the river. The bottom of the lake is firm sand and gravel, and the shores slope off rapidly into deep water, the depth being 40 feet at the center.

It is a very clean lake and in this respect presents a marked contrast to the Lake of the Woods. For vegetation pickerel weed (*Pontederia*) was common around the shores, the largest patch being along the northern margin. The broad-leaved pondweed (*Potamogeton amplifolius*) and Robbins's pondweed (*P. robbinsii*) were found in large patches, and *Chara*, probably *fœtida*, was also common. There were plenty of white water lilies but no spatterdock (*Nymphæa*). Great patches of ditch moss (*Philotria*), considerable wild celery (*Vallisneria*) and hornwort (*Ceratophyllum*), and some *Naias*, *Cladophora*, bladder wort (*Utricularia*), and *Decodon*, and in one place some *Nostoc* were found in shallow water. The water temperature at the surface near the center of the lake was 79° F.; the plankton was very light, containing no vegetation and but a few water fleas (*Cladocera*).

A careful examination of the entire margin of the lake yielded eight specimens of *L. luteolus*, widely scattered, and a half dozen *A. grandis*. The mussels were too far apart to breed well and all were stunted in size and peculiarly fragile at the hinge.

For food the stomachs of the *A. grandis* contained one *Cosmarium*, two or three *Cœlosphæriums*, a few *Clathrocystis*, and one *Ascaris*. In the *L. luteolus* were found one *Anuræa* and a little *Clathrocystis* mixed in a dark gritty mass. Here where the mussels are nearly starved they seem to digest well. (It is common where food is abundant to find undigested organisms at the posterior end of the mussel's intestine, but such was not the case here.)

Station 7. Yellow River at Hibbard.—The water of the river here was perfectly clear and had a maximum depth of 3 feet. The bottom was of fine sand, coarse gravel, and here and there a mud bar, particularly along the shore. The current was rather slow, not more than 2½ miles an hour, and the temperature was 78° F.

For vegetation there were lodged masses of algæ, some *Cladophora*, and patches of the river pondweed (*Potamogeton fluitans*) and aquatic moss. There were also many small sponges scattered over the rocky parts of the bottom. A large number of young black bass, some Johnny darters (*Boleosoma nigrum*), and a few black-sided darters (*Hadropterus aspro*) were found on the mussel beds. Only a few mussels were found in the muddy places, chiefly *U. gibbosus*,

A. grandis, and *L. ligamentinus.* None occurred in the shifting sand, but where the sand was firmly packed and among the rocks they were placed almost as thick as they could lie. *L. ventricosus* and *U. gibbosus* were most abundant and occurred in about equal numbers. The *ventricosus* were all upright, the tips pointed upstream, and the entire mussel buried with the exception of the large brown siphons. The *gibbosus* were more active, moving about in every direction, and often found lying flat on one side. *S. costata* was also very common and when buried, with only the crinkled edge showing, was easily mistaken for *undulata.* A single *L. rectus* was found lying upon its back and spawning. Nearly all the *costata* also were gravid, and most of them contained one or more dorsal baroques, yellowish in color. The *Q. coccinea* nearly all had pink nacre.

The shells obtained at this station were of large size, particularly the pocketbooks (*L. ventricosus*), and of excellent luster. And it is certain that a qualitative examination would show them to be as valuable as any obtained during the entire summer.

Station 8. Yellow River at Burr Oak.—This is the station where the boat and outfit were launched for the trip down the river. The conditions were identical with those at Hibbard, except that the current was a little swifter—4 miles an hour. *Potamageton natans*, *Cladophora*, and *Tetraspora* were found in patches on the mussel beds. As before, the mussels were found mostly in the gravel and hard sand and were completely buried, except the siphons. Many of the *ventricosus* and some of the *gibbosus* were spawning and it was noticeable that the small fishes, especially *Notropis blennius*, *Boleosoma*, and *Semotilus*, which were the ones most abundant, kept playing about near the spawning mussels.

Station 9. County Line Bridge, 4 miles west of Burr Oak.—This was a broad, pond-like stretch of river, with a sluggish current, plenty of spatterdock and white water lilies, a bottom of hard mud and fine gravel, and banks of seepy blue clay.

Not many mussels were collected here—just enough to show that they were still scattered plentifully along the river bottom.

Station 10. Zinc Bridge at Ober.—The water was shallower than at the preceding station, with a maximum depth of only 2 feet, and a current of 5 miles an hour; the other conditions were the same.

The mussels were thickly scattered everywhere, with especially dense beds along the shore. The small fish were again noticed playing about in the immediate vicinity of the spawning mussels.

L. ventricosus has a habit of moving its bright yellow siphon fringes, which are much enlarged during spawning, back and forth in the water. This undulatory motion seems to attract the small darters and minnows, particularly *Notropis blennius*, which could

be seen darting in toward the fringes repeatedly. It also probably assists in furnishing fresh water for the respiration of the young mussels.

At intervals during the undulations small numbers of glochidia are discharged from the brood chambers of the mussel and carried out of the excurrent aperture. These glochidia are of the hookless type, and must be taken into the mouth of the fish that is to carry them during their parasitic period. We can thus understand the advantage of attracting these fish and keeping them in the immediate vicinity during the discharge of the glochidia.

Since this is the last station before the dredged portion, which includes all the remainder of the Yellow River, we may summarize the results.

This stretch of river from Plymouth to Ober, a distance of 20 miles or more, forms an ideal breeding ground for mussels. The natural conditions are exactly suited to mussel life; there are the right kinds of river bottom, plenty of lime and food in the water, and a current of fairly uniform velocity; the water is kept reasonably cool by the springs and brooks which flow into the river, and there are plenty of small fish to distribute the glochidia.

The river is already well stocked with mussels whose shells are far above the average in size and quality, as can be readily seen by reference to the table of values given on page 39. Furthermore, these mussels are not irregularly distributed in small patches, but form a single bed which is practically continuous for the entire 20 miles. With such natural resources it would be a very easy matter to keep the river stocked with mussels that would yield the farmers a far better revenue than any of the swamp land found in the immediate vicinity. A judicious use of the supply already at hand, selecting the larger mussels and leaving the smaller ones unharmed for further development, and replenishing the stock regularly by introducing small fish richly infested with glochidia, would insure ample returns for a long series of years.

The new mussel hatchery just started at Fairport, Iowa, will be able to supply the fish carrying glochidia. Furthermore, the proved quality of the mussels, particularly *L. ventricosus* and *L. ligamentinus*, would make of this a profitable region from which to obtain glochidia for supplying that same hatchery. The railroad facilities at Plymouth, Hibbard, Ober, and Knox are all that could be desired, and there is no trouble in navigating the river between these points in an ordinary rowboat, as was proved beyond question by the present expedition.

Station 11. Old bed of Yellow River below Ober.—No greater contrast could well be imagined than that which was actually presented between the strip of river just described and that same river

bed from Ober to where it empties into the Kankakee, all of which has been artificially dredged. The dredged portion begins 1 mile west of Ober, and since the sole aim of the contractors was to cover the greatest possible distance at the least expense, irrespective of natural scenery, animal and vegetable life in the river, or in fact anything else, they did not follow the old winding channel, but cut across country in a straight line, which intersected the old bed at various places. This dredged part is of nearly uniform depth, from 1 to 3 feet, with a flat bottom of sand and gravel, which the swift current washes up into ripple marks, zigzagging across the entire width of the river. The current is uniform from 4½ to 6 miles an hour and keeps the finer sediment in constant motion along the bottom, thus forming an effectual barrier againt mussel life. Hence, although this stretch has been dredged eight years, and there was an abundant mussel fauna in the old channel, which was not killed off except in limited areas, and which might easily have established itself in a much shorter time in the new channel if the conditions had been favorable, practically no progress has been made in that direction.

An occasional *L. ventricosus* was found alive in the dredged channel, together with shells of *Q. rubiginosa*, *L. iris*, *L. ligamentinus*, *L. luteolus*, etc., which had recently died (probably washed in from the old channel).

No real restocking can be expected until the bottom gets thoroughly solidified, packed down so that it will not wash along continually, and until at least some breaks in the current are formed similar to those in the old channel.

All the mussels found in this long stretch of 20 miles were obtained from the old channel, and it was very interesting to see how completely they had accommodated themselves to the changed conditions. Instead of a good current running over a sandy or gravelly bottom and keeping everything clear and clean, we now find lagoons and bayous in which the water is practically motionless except during floods.

Consequently, they are rich in algæ and other water plants, and the firm bottom has been covered with soft mud and in many places with fine ooze, 2 feet or more in depth. And yet the mussels have remained, *Q. pustulosa* being the only one killed off to any extent. The others have succeeded in climbing up on top of the mud and ooze as fast as it was deposited. Even the large and heavy *rectus*, *ventricosus*, and *undulata* are found on the very top. How such an unwieldly bulk as a full grown *undulata* can move about and actually lift itself up through mud so soft that it will not hold up an empty shell is difficult to understand. But the undoubted fact remains that they actually accomplish it. A noticeable peculiarity of all these lagoon mussels was the presence of a large tuft of growing

algæ around the siphonal (upper) end of the shell. These would be a manifest aid in oxygenating the stagnant water in which the mussels live, and might also be of assistance in keeping them on top of the mud, just as webs of gossamer keep spiders suspended high in air and enable them to perform aerial journeys.

Of the mussels found *luteolus* was far the most common; then came *ventricosus*, *undulata*, and *rectus*, in the order named. Many of the *luteolus* and *ventricosus* and one *rubiginosa* were gravid. *Atax ypsilophorus* was found in nearly all the species and was especially common in *luteolus*, *ventricosus*, and *edentulus*, and many of the eggs and young were found in the mantle. All of the *rectus* shells had a deep pink nacre, as did also one *ventricosus* and one *ligamentinus*. Both of the *imbecillis* found were gravid and were imbedded perpendicularly in the mud, with the siphons pointing straight upward, a very unusual position for that species.

The minnows and darters were abundant on the mussel beds, as is shown by the list of those obtained. *Notropis blennius* and *Boleosoma nigrum* were most in evidence and could be found everywhere, while the others were more scattered.

Only a few mussels were collected below Knox, and they have been recorded with the others from the old river channel. With the account of the Twin Lakes which follows, this concludes the investigations on the Yellow River.

Station C. The Twin Lakes.—These "twins" are really four in number, grouped near the center of the western third of Marshall County in two pairs, separated by the Vandalia Railroad. The eastern pair are elongated in a northwest and southeast direction and lie in the same straight line. The eastern and smaller one is Lorance Lake, about 80 rods in length and width. It is separated from the larger lake by a stream 50 rods in length. The larger is called Meyer's or East Lake and is a mile in length and about 40 rods wide. The western pair on the other side of the railroad are elongated at right angles to the others, or in a northeast and southwest direction, and they lie side by side with their long diameters parallel. The northern, larger one is Cook or Northwest Lake, and is the same size as Meyer's. The southern one is Holem or Southwest Lake and is about three-quarters of a mile long and 30 rods wide. It is separated from Cook Lake by a narrow ridge of gravel, 15 to 20 feet high and 200 to 300 feet in width.

Lorance Lake empties into Meyer's through the short brook mentioned. Meyer's runs under the Vandalia Railroad track into Cook; Holem also drains into Cook from its southwestern end and Cook delivers the drainage of all four lakes into Eagle Creek, which empties into the Yellow River just above Knox. All the lakes are very shallow, the maximum depth being under 20 feet, and the area

drained into them is limited. In general, they are surrounded by high banks of clay with only a little sand and gravel. They are fed largely by springs, nearly the whole shore line being marshy, with only a few bits of sandy beach.

Three of the lakes, Lorance, Meyer's, and Cook, were carefully examined for mussels; nothing was found in the one first mentioned; the other two yielded returns as follows:

East Lake (Meyer's) is considerably the shallower and warmer of the two; the bottom is a firm sandy marl, with scattered patches of *Chara* and *Potamogeton*, while the shores were fringed with pickerel weed, water lilies, reeds, bulrushes, and similar vegetation. The mussels were rather widely scattered, but formed beds where they did occur. Only two species were found, *Anodonta grandis* and *Lampsilis subrostratus*, the former in far greater abundance than the latter. The *subrostratus* yielded no parasites at all, the *grandis* were fairly loaded with them, every specimen yielding large numbers. They included *Atax* of several species, prominent among which was a rather small, deep-red one, *Cotylaspis*, marginal cysts, and the distomid of Osborn. The cysts of the marginal distomid were especially abundant and number hundreds in many of the specimens, while one must have had fully a thousand. The distomid of Osborn formed great pink patches under the umbo and tinged nearly all the shells with a reddish salmon color.

Northwest Lake (Cook) is deeper and the water was clearer and colder. Like East Lake the bottom is a firm sandy marl, covered in many places with *Chara*. The shallow water along the shore was one solid mass of reeds, bulrushes, and lily pads. The mussels were widely scattered and the same two species were found as in East Lake, with the addition of *L. luteolus*. As before, *grandis* was much the more common; the older examples were found with their shells high out of the sand, just enough being buried to hold them in place. The younger examples were more deeply buried. Many small fishes were seen upon the mussel beds; they included *Notropis blennius*, *Fundulus dispar*, and the young of *Lepomis pallidus* and *Erimyzon sucetta*.

Samples of plankton were secured from the clear water in the center of the lake at a depth of 8 feet. There were found five species of copepods, most of them covered with *Vorticella*, small pink water mites, *Daphnia*, a few nauplii, *Lyngbya*, minute *Spirogyra*, *Anuræa cochlearis*, *Ceratium hirudinella*, *Fragillaria crotonensis*, and *Anabæna*. This was the richest plankton obtained during the summer, and yet the water appeared perfectly clear.

On examining the mussels they were found to be as badly infested with parasites as those of East Lake, but here the *Atax* and *Cotylaspis* were far more numerous, and there were not as many

cysts. Some specimens contained 30 or more of the adult parasites, besides innumerable young swarming over the gills or the mantle.

The bed of mussels along the center of the north shore gave a remarkably fine opportunity to study the activities of the mussels in the natural beds, as the perfectly clear, calm water enabled one plainly to see them carrying on their life processes. The species examined was the *Anodonta grandis* of the lake, a plump, inflated form which probably represents the subspecies *footiana.*

The inhalent aperture was very large, black exteriorly and for some distance in. It was possible to look in far enough to see the gills. Long papillæ in approximately a single row project directly across and nearly to the center of the siphonal opening; most are single, but a few may be forked. The incoming current of the mussel is not nearly as strong as the outgoing, since the latter has a much smaller cross-section for the same amount of water. Minute red water mites ventured to the very orifice of the inhalent aperture but were not swept in, while small objects coming near the exhalent opening would be driven away with some force.

The exhalent opening was black for some distance in, then faded out to white. It was possible to see the posterior opening of the alimentary canal and the water-tubes running down into the gills of the living mussel. These mussels were quite apathetic; they did not close up at near approach, which must have caused both shock of waves and shadow. One, taken from the bed, closed only for a moment, then opened and began feeding while held in the hand. River mussels in general are more sensitive, and sometimes close when simply a shadow passes.

Station 12. Potato Creek, Kankakee River.—Having finished the workable portion of Yellow River, our attention was next directed to the headwaters of the main Kankakee.

At its source this river forks like the Yellow River, the west fork rising in the Fish Lakes, the east fork in the swamp southwest of South Bend. We found conditions here similar to those at the headwaters of Yellow River, but with this difference: While the east fork and the main river have been dredged recently down to the entrance of the Yellow River and about 10 miles beyond, many of the tributary creeks have been left in their original conditions; and since the west fork has been dredged only here and there, the Fish Lakes, at its source, remain practically unchanged. We were thus able to combine in our examination natural with artificial conditions, and we found an even stronger contrast between the two.

This entire section was worked by short drives from Walkerton, in the extreme southwest corner of St. Joseph County, since it was

impracticable to row up against the swift current in the dredged Kankakee above its junction with Yellow River.

Naturally we examined first those portions in which the conditions had been least changed. Potato Creek is the southernmost of several large creeks which empty into the east fork of the Kankakee, and lies just north of Walkerton. The bed of the creek is hard sand or gravel, and, being undredged, it still preserves those alternations of swift and sluggish current, deep and shallow water, coarse and fine bottom, which are conducive to mussel life.

We found in it nine species of mussels, nowhere very thickly bedded, but as many, perhaps, as would be expected in a creek of the size, it being 8 or 10 feet wide, with the water nowhere more than a foot or a foot and a half in depth. On examining these mussels, the *Anodontoides* and the *Anodonta* were found infested with *Atax* parasites and the distomid of Osborn; the other mussels were free.

Station 13. Pine and Yellowbanks Creeks.—These are two other creeks of about the same size as Potato Creek and lying to the north of Walkerton. But, although they presented conditions apparently as favorable as those of the last station and were examined for long distances on either side of the highway, not a single mussel could be found in them, nor any dead shells, with the exception of one valve of *Symphynota compressa* in Yellowbanks Creek.

Station D. The Fish Lakes.—These lakes really occupy a single lake basin which is divided by narrow channels into four bodies of water, known as the Upper Mud Lake, Upper Fish Lake, Lower Fish Lake, and Lower Mud Lake, respectively. The two Fish Lakes have each an area of about 100 acres and a maximum depth of 40 feet. The thoroughfare between them is 80 rods long and 15 or 20 feet wide, with a maximum depth of 2 feet, and has a good current. The water in both of the lakes and the thoroughfare was clear and quite warm. The bottom was marl, hard and firm in most places, but very soft in a few spots. The shallow belt along the shore is narrow, as a rule, though wider and more irregular in the Lower Lake than in the Upper. The banks are high about halfway around each of the lakes, but low and swampy for the other half, where in each case it borders on the respective Mud Lake. There was the usual lake vegetation around the shores—reeds, rushes, spatterdocks, and some algæ.

Mussels were found abundantly everywhere. *A. grandis* was the most common and was found everywhere mingled with the other species. Most of the specimens were exceptionally large. Their shells were also thick and strong; in fact, many of them possessed shells of sufficient thickness for the manufacture of buttons.

L. luteolus was fairly abundant, and, instead of the usual dwarfed specimens found in lakes, these were fully as large as any obtained in the Yellow or Kankakee Rivers.

L. subrostratus was sparingly distributed, only 20 specimens being found, but each of these had large shells for the species, with an exceptionally thick white nacre.

A few *Unio gibbosus* were found in shallow water close to the shore.

A large number of dead shells of *Q. undulata* were scattered about over the bottom, and at one spot in the Upper Lake a colony of living examples was found. This is the first instance in our experience of finding this species in a lake, although Call reports it as fairly common in the lakes of northern Indiana. The shells were all fully as large and of as fine quality as those found in the rivers. A single live specimen of *L. iris* was found near the shore, one of *L. glans*, and one of *A. imbecillis*. All these mussels were well incrusted with marl, but the size of the shells and the healthy appearance of most of the specimens indicate that the conditions are at least very favorable.

A. grandis was as plentifully distributed in the thoroughfare between the lakes as over the lake bottom, but the other species were not found there.

The two Mud Lakes, as their names indicate, had a bottom of soft black muck and contained no mussels.

On the way back to Walkerton another Mud Lake on the east fork of the river, and into which Potato Creek empties, was visited. But the lake has been practically all drained by the dredging of the river and what is left was so black and swampy that it was not deemed worth examining.

The mussels from the Fish Lakes yielded an abundance of *Atax* parasites, some *Cotylaspis*, and many of the distomid of Osborn. The exceptional size and thickness of the shells of all the species is worthy of notice.

Station 14. Kankakee River at Davis, Ind.—The old bed of the river was examined close to the bridge of the Pittsburgh Division of the Pennsylvania Railroad. The same conditions were repeated here as in the dredged portion of the Yellow River below Ober. There was too swift a current and too much moving sand for the mussels to obtain a foothold in the dredged channel, but the old bed of the river was full of them. In this latter locality the hard sandy bottom had been overlaid with 1 or 2 feet of soft black mud, brought down during the freshets and deposited in the quiet water of these lagoons.

The mussels were even more numerous than in the old bed of the Yellow River, three or four being often obtained in a single square

foot of the mud. These mussels also usually had a large mass of algæ attached to their upper ends and forming a sort of funnel in the water. Whatever may be the effect of the supporting power of the algæ in the mud, the two furnish a good example of symbiosis. The mussel supplies the alga with a place of attachment, otherwise lacking, and in return the alga helps to purify and oxygenate the water for the mussel.

Q. undulata was by far the most common species, there being two of them to every one of all the other kinds. No adult *Atax* parasites were found in this species, but the mantles of many of them contained clusters of the eggs.

Each of the *Q. pustulosa* (75 specimens in all) contained from several to a large number of adult *Atax*, besides clusters of eggs in the mantle, and young in various stages of development, swarming over the gills. *Q. coccinea* contained no parasites at all, and the nacre of all but two of them was white and would make excellent buttons. *L. ventricosus* had an abundance of young *Atax* in the mantle and on the gills, and many of them had dorsal baroques.

L. rectus showed anywhere from 10 to 20 adult *Atax* in each specimen, besides plenty of young and an occasional *Cotylaspis*. A marginal baroque was found in one, and the nacre of all was a deep purple. None of the other species contained parasites.

Station 15. Kankakee River at the crossing of the Nickel Plate Railroad.—Just above the railroad bridge is a large island with the old channel to the west of it and the newly dredged one to the east. The water runs through this old channel oftener than at the previous station, so that only a few inches of mud have been deposited. The mussels were very abundant here, forming the largest and most densely populated bed found anywhere in the old channel of either river. There was much driftwood buried in the mud along the west bank of this old channel, and the mussels were clustered around the twigs and branches as thickly as they could stand, seeming to get some support from these solid objects.

Farther up behind the island the water was shallower and there was a perceptible current and no mud. Here the mussels were actively moving about, and as the water was clear they could readily be found.

On examination, none but the *Q. pustulosa* contained any parasites, but these had enough to compensate for any lack in the others. Every specimen was infested, and it was not at all uncommon to find 50 or 60 adult *Atax*, besides the eggs and young, in a single mussel. Many of these mussels contained small pearls and some of them dorsal baroques.

The *Q. coccinea*, again, had white nacre, none of the rosy nacred being found, and being at the same time large and flat, furnished

excellent material for buttons. (See values, p. 39.) The *L. rectus*, on the contrary, were not merely pink, but nearly all of them were deep purple.

The small fishes seined on these mussel beds furnish a good sample of those to be found in the upper part of the Kankakee River. *Boleosoma nigrum* was by far the most common, with *Notropis blennius* second in abundance. *Notropis heterodon* was common and easily recognized by its dark lateral stripe and black chin. We also obtained five examples of *Ericymba buccata*.

Station E. Koontz Lake.—This lake is situated in the extreme northeastern corner of Starke County, Ind. It is shaped like a three-leafed clover, the middle leaflet considerably the largest, and the whole lake covers 200 or more acres. The outlet is at the southwest end, where a stone dam has been built, 10 feet high and wide enough to accommodate a carriage road across its top. This outlet, called at first Cedar Creek, runs west into Robbins ditch, where it is joined by other ditches and becomes 40 or 50 feet wide, or nearly the size of the Kankakee itself, and empties into that river a couple of miles above the mouth of Yellow River and about the same distance below station 15. The outlet was examined for a mile west of the lake but yielded only a single *L. luteolus*.

The lake is in a large measure artificial, being formed by backwater from the dam. It has a hard sandy or gravel bottom and the shallow water around the shore is filled with rushes and lily pads, while the bottom itself is covered with *Chara* and *Potamogeton*, and so does not afford good localities for mussels. In a few places, however, the bottom is of clear sand and here *A. grandis* and *L. luteolus* were found in considerable abundance, and a few *Q. rubiginosa*.

These mussels were all of good size and quality for lake shells. No adult *Atax* were found in the *A. grandis*, but the eggs and young were abundant. Adult *Atax* species were found in all the *luteolus*, in addition to eggs and young. No parasites were present in *rubiginosa*.

Station 16. Kankakee at mouth of Yellow River.—Since being dredged this part of the Kankakee is called the Sisbro ditch. The old channel of the river crosses the ditch here and is available on both sides.

To the north we found a rather deep pool with a solid bottom and only a little mud and containing a large number of minnows and darters. Here we obtained only a few shells, chiefly *undulata* and *luteolus* with some *coccinea* and *pustulosa*. Farther down where the old channel crossed to the south there was running water, shallow in depth, with a firm sandy bottom in places and mud elsewhere. Here the mussels were exceedingly active, and nearly all were found

at the end of long tracks that looped and turned upon themselves. Some *Oscillatoria* was found growing on the quieter shells.

Three or four miles farther down the river the old channel crossed the ditch again. Here in the deeper parts of the pools the mussels fairly touched one another. A pearler had been working on these mussels and had left a couple of large piles of freshly killed shells on the bank.

Along this stretch of river we obtained the first good evidence that the mussels are reestablishing themselves in the dredged channels. Living specimens were fairly common near the shore.

This part of the river was once the bottom of English Lake, a marshy overflow from the Kankakee, 10 or 12 miles long, 2 or 3 in width, and of shallow depth. It was filled with algæ of all kinds, reeds, rushes, water lilies, and an abundance of wild rice, and formed a natural breeding ground for thousands of waterfowl. It must have fairly swarmed with mussels, to judge from the dead shells of those thrown out by the dredge and the large numbers still found alive in every portion of the old channel that contains water. The dredging has entirely drained the lake and it is now a straight cross-country ditch, with the mussels gradually repopulating it. The conditions here are much more favorable than in the Yellow River, and a little artificial restocking would restore the mussel fauna in a few years.

On cleaning the mussel shells we found them an interesting lot. The *L. luteolus* were all more or less blistered and steel-colored at the tips of the valves, and frequently the whole shell was curiously roughened. They yielded many small pearls, all located near the tip of the mantle in the region of the siphons. And they usually had a number of young *Atax* crowded around the exhalent orifice. So far as our experience goes this is a rather unusual position for young *Atax*. Their ordinary situation is along the lips of the inhalent aperture. *Q. pustulosa* also contained many *Atax*, but they were not as numerous as at station 15. Four of the *Q. coccinea* had white nacre and all the *L. rectus* were pink instead of the deep purple of those farther up the river. Parasites were also found occasionally in *L. ventricosus*, *L. ligamentinus*, and *Q. undulata*. A few of the *ventricosus* and *luteolus* were gravid or beginning to become so.

Station F. Bass Lake, Starke County, Ind.—This lake is fourth in size among the Indiana lakes and covers an area of 2¼ square miles. It lies in the southeastern part of the county, about 6 miles south of Knox. It is somewhat boot-shaped, the leg portion elongated northeast and southwest, the foot portion at right angles to this. It occupies a shallow basin on the top of a morainic ridge and more than half of its area is 5 feet or under in depth; the maximum

depth is 32 feet. The greater part of the shore line is low and marshy, and the water is filled with a dense growth of reeds and rushes. The bottom is sand or blue and sticky clay, interspersed with extensive muck beds, the latter giving rise to a luxuriant growth of aquatic vegetation. The sand and clay are also covered with algæ, among which is *Chara*. *Potamogeton* is also common. In fact the lake flora is richly developed at the expense of the fauna. At present the lake has no outlet or natural inlet, but is fed entirely by springs. The old outlet, however, now so filled that water runs through it only occasionally, was to the west, emptying into the Kankakee about 3 miles below station 16. Dwarfed *L. luteolus* were fairly common in the gravelly sand close to the shore, and there was a large bed of them around a point which juts out into the lake from the eastern shore, Cranberry Point. A few *A. grandis* were also found. Both species were infested with *Atax* parasites, but not in large numbers, and in addition *Cotylaspis* and the distomid of Osborn were present in *A. grandis*. This lake had been examined in 1906, and a number of *Anodontas* obtained near the ice houses and *Lampsilis luteolus* on the opposite shore.

Station 17. Kankakee River, Riverside, Ind.—On the way down from English Lake to Riverside small piles of mussel shells that had been left by pearlers were frequently found. Here the mussels have fully reestablished themselves in the dredged portion of the river, and the steep banks just under the water were well lined with *L. luteolus*.

Just above Riverside the dredged ridge along the north bank of the river held back a small pond covered with *Euglena* in a portion of the old channel. This was nearly filled with soft mud and contained but few mussels, though there were plenty of dead shells along the bank. On this stretch of river there was a marked increase in the number of *ligamentinus* and *ventricosus*. All the shells found were large and of excellent quality.

Station 18. Burrow's Camp to Baum's Bridge.—The dredged portion of the river stopped at the last station and we now entered the genuine Kankakee swamps. The sides of the river were low and boggy but heavily wooded for a short distance back from shore. The bottom we found to be firmly packed sand, admirable for wading, and there was a current of 4 miles an hour.

Mussels were plentiful along the shore wherever the bottom could be seen, and we waded often enough to show that they continued into the deeper water. There were occasional piles on the banks, left by fishermen and pearlers, and in one of the shells thus left a small pearl was found. But only one of the live *luteolus* yielded pearls, a much smaller percentage than farther up the river.

Every specimen of *pustulosa* was infested with *Atax* parasites and most of them contained dorsal baroques. The *ventricosus* specimens contained both *Atax* and *Cotylaspis;* two of them were gravid and one had two dorsal baroques. The single *A. grandis* was the first one found in the Kankakee River.

Station 19. Baum's Bridge.—Just below the bridge is a clubhouse belonging to the Crawfordsville Club. We stopped over night with Mr. George Wilcox, the keeper of the clubhouse, who, besides entertaining us hospitably, gave us much valuable information in regard to the river. He told us of a mussel fisherman who had gone down the river two years before and who had obtained several hundred shells from a bed in front of the clubhouse. We had also been informed that button manufacturers had sent out circulars along the river offering $20 per ton for good shells, and that people along the river who had sent in samples had been offered from $5 to $8 and $12. We tried our dredge in the same place, a sort of eddy in the current. The water was 8 to 10 feet deep and the bottom of hard sand and fine gravel with some lumpy blue clay. The mussels were abundant both in the sand and at the edge of the clay. Most of the specimens were *undulata*, but there were many *luteolus* near the shore and some fine *ligamentinus*, *rectus*, and *coccinea*. Several of the *ligamentinus* were gravid, and most of the *coccinea* had white nacre. Nearly all the *luteolus* contained *Atax* and *Cotylaspis* parasites and 5 out of the 32 had small pearls in the mantle edge.

Station 20. Hebron Bridge, Kankakee River.—The river widens out into a sort of lake about 3 miles above this bridge. The bottom was firm sand and nearly uniform, not more than 4 feet deep at the maximum, with large patches of water lilies and smartweed, and plenty of *Potamogeton fluitans* along the banks.

Mussels were found all over the bottom, but were most plentiful among the roots of the *Potamogeton* along the shore. Nearly all the *L. luteolus* were found there, while the *ventricosus* and *ligamentinus* were in midstream and proved exceptionally large and fine. *Q. undulata* was also common in the deeper water, but there were almost no *Q. pustulosa*. The three specimens of *S. complanata* were the first found in this river.

Most of the *luteolus* and *ventricosus* were either gravid or becoming so, and, together with the *undulata*, were each infested with a few adult *Atax*, and often with eggs and young parasites; and many contained also *Cotylaspis*. The *luteolus* averaged about one pearl apiece in the edge of the mantle, while the *ventricosus* contained dorsal baroques. The other species were free from parasites.

Station 21. Water Valley, Kankakee River.—The collection here was obtained from three different localities: (1) Hog Wallow Slough,

a marshy lagoon on the north bank of the river with water 2 or 3 feet deep and a hard bottom of sand; (2) the south bank of the river, which is in the town of Thayer and where some pearlers had left a pile of about 100 shells all freshly killed; and (3) the middle of the river between the two places, where we used the dredge in water about 6 feet deep, with a hard sandy bottom and very little current.

At the slough the mussels were scattering, but of excellent size and quality. In the pearlers' pile, which were all *luteolus*, we found many pearls of small size in the edges of the mantles. From the deep water of the midriver were obtained *coccinea* (in deep water only), *undulata*, and *pustulosa*. Shells are said to be easily obtained in large numbers here at low water. Many of the *ventricosus* were nearly gravid, and the *luteolus* were all infested with *Atax* and *Cotylaspis* parasites, though the other species were free.

During our stay in Water Valley we stopped with Mr. John Phelps, a fisherman who is thoroughly acquainted with the Kankakee River, and who gave us much valuable information in reference to the mussels as well as the fishes. Through his courtesy we had an opportunity to examine many of the fish caught in the river.

The redeye, *Ambloplites rupestris*, yielded a few specimens of *Ergasilus centrarchidarum* attached to the gill filaments. Another specimen had mussel glochidia on its gills, while a third one was covered with bloody spots over the outside surface of the body, most common near the anal fin. Attached to one of these spots was a *Lernæocera cruciata*, which Mr. Phelps told us were quite abundant on this fish in the early spring. These redeyes, together with the large and small mouthed black bass and the sunfish, all of which are plentiful in this portion of the Kankakee, have proved to be the most satisfactory species for carrying glochidia (Bulletin of the Bureau of Fisheries, vol. XXVIII, p. 624.) Their presence, therefore, insures one of the most important conditions for the success of artificial mussel propagation.

Station G. Cedar Lake, Lake County.—This must have been a favorite name with the early settlers, judging from the fact that there are at least six "Cedar" lakes in the State of Indiana. This particular one is in the center of Lake County and covers 1.17 square miles, being a little over 2 miles in greatest length and about three-quarters of a mile in greatest breadth. It is shaped like a kidney or bean, and owes its origin to irregularities in the deposition of the drift material. It is surrounded on all sides except the south by heavily wooded ridges, which formerly were its shores. It is another case of artificial drainage, like the Lake of the Woods.

In order to reclaim 200 acres of comparatively worthless marsh land at the southern end of the lake, a ditch was cut on its eastern side which lowered the level of the lake 10 or 12 feet. This artificial

ditch is the present source of Cedar Creek, which flows south into the Kankakee River.

The present shores are hard and firm and the bottom is sandy along the north and east sides and muddy along the west and south sides. Both sand and mud are covered in many places with *Chara* and *Potamogeton pusillus*, mixed with some *Vallisneria*, *Philotria*, and *Cladophora*, the latter on the pebbles. Along the shores are reeds and rushes, forming a thick fringe.

The water of the lake was remarkably green, due to the presence of minute suspended algæ, mostly *Clathrocystis*, with some *Lyngbya* and *Anabæna*. A tow taken at the surface near the center of the lake yielded a wineglassful of Entomostraca, chiefly copepods and *Daphnia*, much the richest haul of any taken during the summer.

In front of the Siegler Hotel, on the west shore, is a broad sand bar used for bathing. Here, just outside the bathing rope, in 6 feet of water, was a thick bed of mussels, nearly all *A. grandis*, with a few dwarfed *L. luteolus*.

Mr. Siegler kindly furnished us with a boat and a long-handled rake with which to secure our specimens.

We were told at the hotel that formerly the people about the lake were accustomed to cook and eat the *Anodontas* with much relish, but had gotten out of the habit in late years. An examination of the eastern shore showed that the *A. grandis* was very plentiful there, but *L. luteolus* was scarce.

A seine haul just south of Cedar Point gave us the largest number of small fishes obtained during the season, mostly *Labidesthes sicculus* and *Boleosoma nigrum*. Evidently the abundance of Entomostraca produced its legitimate effect.

On examining the mussels, all the female *luteolus* were found to be gravid and infested with a small red *Atax*. Only one or two of the *grandis* were gravid, but they were all badly parasitized, containing from 5 or 6 to 30 *Atax*, chiefly *A. ypsilophorus*, and a few *Cotylaspis*. No pearls were found in any of our specimens, though we were told many had been obtained from the *Anodontas*.

Station 22. Burtons Landing, Kankakee River.—This station was on the south bank of the river just above where the dredged ditch empties in.

The bank was very steep, giving 4 or 5 feet of water close to the shore; the bottom was mixed sand and mud; the current was slow and there was no vegetation present. The mussels proved to be abundant, both along the shore and in the deeper water of the mid-river, *Q. undulata* being the most common species. It was noticeable that there were no mussels in the sand brought down by the ditch. A broad delta had been formed, reaching far out into the river, but the mussels carefully shunned its shifting sands. Furthermore, all

those on the down-river side, which had been caught by these same sands, were dead, another striking testimony of the effect of a shifting bottom on the mussel fauna.

All the *luteolus* and *pustulosa* were infested with *Atax*, one *pustulosa* yielding 61 of the adult parasites. The *luteolus* also contained a few *Cotylapsis;* the other species were free.

The two *A. grandis* and the single *S. complanata* are worthy of note in view of the rarity of the species in the river.

This is the last station in the swamp region of the Kankakee, and it may be well to give a brief summary of the conditions prevalent there.

This length of the undredged portion of the river from English Lake to the State line is variously estimated by different authorities. A conservative estimate would make it at least 100 miles, and it is practically one continuous mussel bed for the entire distance. There are places where the mussels are thicker than elsewhere, but there is hardly a spot where search will not reveal at least some species.

We have here again an ideal breeding ground for mussels, similar to the Yellow River from Plymouth to Ober, but at least five times as large. The natural conditions are even better here than they were in the Yellow River; there is the same kind of a bottom, lime and food enough in the water, a good current the whole distance, and plenty of small fish to distribute the glochidia.

Then there is in addition the great swamp reservoir to regulate the supply of water, the organic material derived from the swamp vegetation to serve as food, and the enforced seclusion of the region to obviate any disturbing influences. There are several valuable species of mussels, like *rectus*, *pustulosa*, and *coccinea*, which were not common in the Yellow River, but which would add greatly to the value of the mussel product; and finally we find the mussels here infested with the same pearl and baroque producing parasites.

Instead, therefore, of expending large sums of money in an artificial drainage system, thereby entirely destroying the natural resources of the region, making it of no possible use as a game or fishing resort, and annihilating its rich mussel fauna, all for the sake of reclaiming a few hundred acres of land that have not proved to be worth much, it would seem to be far more profitable to cultivate the resources already in existence.

Nature has herself clearly indicated the kind of products suited to the region. Now that man has learned how to handle one of the most valuable of those products, mussel shells, it would require very little effort or expense to convert the native mussel fauna into a rich source of revenue. The *L. rectus*, which has white nacre, called the "white sand shell" by the mussel fishermen, could be easily intro-

duced, and would produce shells that bring large sums of money in the market. The hunting and fishing would not be injured, but rather benefited by the increase of the mussels.

Here is an ideal chance for the breeding of mussels on a large scale; it only needs to be once started to prove its value. Furthermore, the mussels are infested with the same kinds of parasites as those of the Yellow River, while pearls and baroques are even more plentiful. Consequently, the prospects of a reasonable bonus from this source are exceptionally good.

Station 23. Kankakee River between the State line and Momence, Ill.—Just across the State line occurs the first limestone outcrop in the bed of the river. This is the ledge which has acted as a natural dam and prevented the wearing down of the river bed. Were it not for this ledge the river would have long since drained the immense swamp region. But just as it is responsible for the character of the channel above it in Indiana, so it marks the beginning of a very different kind of channel below it in Illinois. In the 50 miles of river from the State line to the head of the Illinois, the Kankakee falls 130 feet, or nearly 3 feet per mile. From a deep and smoothly moving river, without a break between its source and the State line, it is suddenly converted, on passing this ledge, into a succession of broad and shallow rapids difficult to navigate. The old bed of sand and fine gravel ceases and in its place we find shelving rocks, coarse gravel, and bowlders.

Such radical changes in the surrounding conditions would suggest that the mussel fauna must change also, and such we find to be the case. Several additional species appear all at once and are common down to the mouth of the river. We no longer find a continuous bed of mussels, but they are scattered wherever they can find a foothold. For long distances the solid rocky bottom prohibits them from remaining; then come favorable localities where they are packed as closely together as they can lie. In general, the conditions are not as favorable in Illinois as in Indiana; it is certainly very much more difficult to gather the mussels. Our first collection within the State, however, was made rather easy by the fact that pearlers had been at work along the river and had left small piles of shells scattered here and there on the banks. We selected from these and supplemented them with living specimens of other species. Near the State line some *undulata* were found with a yellowish epidermis instead of black.

Station 24. Momence, Ill.—Just above the town was the camp of three mussel fishermen who had been collecting shells from the immediate vicinity for the market. They had secured about 15 tons, the only culls from which were a few *U. gibbosus*. They told us the shells from this locality were not as tough as those in the Wabash

River, and hence did not bring quite as much per ton. They showed us a good collection of pearls and baroques obtained from their mussels, and just as we landed they picked a large spherical pearl the size of a pea out of the mantle of an *L. ligamentinus*. We looked over their pile of shells and took samples of the different species; the great bulk of the pile was *ligamentinus* and *ventricosus*.

We secured the following species which had not been found in the river above: *L. ellipsiformis*, common; *Q. tuberculata*, several; *Q. metanevra*, rather common; *A. truncata*, frequent; *S. edentulus*, two; *S. costata*, common and large; *O. ellipsis*, two. Some of the *L. rectus* had white nacre, but most were pink; the *U. gibbosus* showed purple, pink, and white nacre, with considerable difference in shape and size of shells.

Station 25. Waldron, Ill.—The river was shallow and rocky and very difficult to navigate below Momence, but the water was fairly clear, so the shells could be seen on the bottom. There was considerable *Potamogeton lonchites* and water willow along the water's edge. Beds of mussels could be seen in various places, especially near the riffles; but as the mussel fishermen at Momence had worked this part of the river thoroughly, no stop was made until we were close to Waldron. Here was found a pile of freshly cleaned shells, about one-quarter of a ton, which had been left by pearlers. Samples of the different species were selected and kept; the pile was nearly all *L. ligamentinus*, with some *L. ventricosus* and *U. gibbosus;* the other species listed occurred in small numbers. One of the *L. rectus* had white nacre, the first white-nacred one seen; the rest were pink. Both the *ligamentinus* and the *ventricosus* had been gravid in considerable numbers when captured.

At Waldron an 8-foot dam prevents all intercourse with the river farther down.

Station 26. Watseka, Iroquois River.—This river is the chief tributary of the Kankakee in Illinois as was the Yellow River in Indiana. Like the main river, the character of this tributary changes radically at Watseka. Nearly half the river basin, 800 square miles, lies in Indiana, and is of the same type as the Kankakee Basin in that State, marshy and sandy.

Just before reaching Watseka, Ill., it crosses the so-called Iroquois moraine and afterwards traverses an old lake bed. There is much more fall in the river, but it is never as rapid as the Kankakee. The great amount of dry prairie land it drains makes it a "flashy" river, subject to rapid rise and fall, and hence the upper portions of it are not very rich in mussels. Furthermore, in the vicinity of Watseka the banks of the main river and of Sugar Creek, a large tributary from the south, are so steep and slimy with clay that it was practically impossible to do any wading. The collection of

shells from this station, therefore, includes simply what could be picked up along the shore.

About a dozen years ago a Mr. Hill started a woolen factory in Watseka for the manufacture of woolen goods, and, as an adjunct to employ the surplus water power and to furnish the buttons for the goods he turned out, operated a button factory. The farmers along the Iroquois River and Sugar Creek kept him supplied with shells, which they gathered and carried to the factory. A flourishing business was done for six or eight years until hard times came and caused the shutting down of both factories. Enough was accomplished to prove that these two streams contain a plentiful supply of shells—enough to run such a factory for a long time.

Station 27. L'Erable, Iroquois River.—This is about 10 miles below Watseka, but the river widens in that distance from about 40 feet to fully 175 or 200. It was about 3 feet deep at the center, with a bottom of fine gravel along the channel bordered on each side by sand, while the banks were soft clay mud. The current was almost imperceptible and the water very muddy. The mussel fauna was rich and varied, as the list given amply proves, and the species were fairly well sorted according to the kind of bottom.

In the soft mud were found *luteolus* and the first *fallaciosus* we had seen, with an occasional *ventricosus*. In the sand were a few *lachrymosa*, also the first found in the Kankakee Basin, *pustulosa*, *undulata*, *complanata*, *costata*, and *rubiginosa*. In the gravel was the great majority of the *lachrymosa* and *undulata*, with an occasional *ventricosus* and *complanata*. *Q. lachrymosa* was more abundant than all the other species taken together, and in many places were so thick one could hardly get a foothold without standing on them. The shells were exceptionally large and of fine luster and quality.

On examining the mussels for parasites, nearly all the *complanata*, *luteolus*, *pustulosa*, *trigona*, and *lachrymosa* were found to be infested with *Atax*, the distomid of Kelly, and marginal cysts. A few of the shells contained pearls and dorsal baroques, but in much smaller numbers than were found in the mussels of the Kankakee River. A small number of each of the species just named were gravid, the others were free from parasites, and in none of them had the eggs passed down into the gills. While most of the *rubiginosa* had the characteristic reddish orange meat. a few were found almost white.

The Iroquois is a river of *Quadrulas*, with comparatively few *Lampsilis*, in marked contrast to the Yellow and Kankakee Rivers, which are nearly all *Lampsilis*, with comparatively few *Quadrulas*.

Station 28. Iroquois River 3 miles above its junction with the Kankakee.—The change in the bed of the river already noted was

even more apparent here; the river was shallow and full of riffles and the bottom was almost continuous rocks, with little sand or mud between them. But the shores still showed the obnoxious black clay mud.

Fortunately, the muskrats had been busily at work eating the smaller mussels with some of the large ones, and had collected large piles in many places. The mud on shore was nearly a solid network of muskrat tracks, with here and there the long groove where they had dragged a shell too large to lift and carry. They evidently had no trouble in finding plenty of mussels, although we could not locate the live ones among the rocks. The 15 species listed were all obtained from the muskrat piles, and, as will be seen, include *Q. metanevra*, which evidently prefers localities with a very rocky bottom.

Station 29. Mouth of the Iroquois River.—Where the Iroquois joins the Kankakee, there are two or three small islands, raised but little above the level of the water, but giving support to a mass of dense underbrush.

Here again the muskrats had nearly covered the mud around the roots of the bushes with nicely cleaned mussel shells of many species—probably all that can be found in the vicinity. Two *Q. lachrymosa* were found alive at the water's edge; all the others collected were the shells from the muskrat piles.

Station 30. Kankakee, Ill.—Several pearlers had been at work on this portion of the river and about 1 mile above the city of Kankakee were two large piles of shells close to the water's edge on the south bank. The first pearler, and evidently the more experienced one, had collected only *L. luteolus*, but his pile of shells did not show proof of having yielded many pearls. The other party had collected all species indiscriminately, and 14 different kinds were found in the pile. None of these shells gave evidence of having been much parasitized and probably did not yield very large returns. They gave us a fine collection from the locality, however, without the trouble of wading and hunting for them.

The selection of *luteolus* as a pearl producer is worthy of notice, since it coincides exactly with our own experience in the whole Kankakee Basin. The pearl problem is quite possibly different in each river. In some rivers *Q. undulata* or *plicata* are regarded as the pearl-bearing shells; in others, *L. ligamentinus*, and so on. In the Kankakee *L. luteolus* was the most prolific, and indeed the only species that one could count on to yield them, but the pearls were all, though perfectly spherical and of good luster, of very small size, called by the pearlers "mustard-seed pearls."

Station 31. Custer Park, Ill.—Just below the city of Kankakee there are five large dams across the river within a few miles, while at Altorf and Wilmington there are rapids with a sudden descent of 20

feet in the river. These make this part of the river unnavigable. Accordingly, the boat and outfit were shipped from Kankakee, and the remaining portion of the river was worked from the railroad.

From Wilmington, the nearest station, we drove to the house of Mr. Jesse Fairchild, on the north bank of the river. He kindly lent us his boat and told us where to find a mussel bed, which he said was the only one for some distance up and down the river.

It lay along the edge of a riffle where the water was about 2 feet deep and the current 5 or 6 miles an hour. The bottom was entirely covered with stones of all sizes and shapes, mostly well rounded, and thrown together with small pockets between them. These pockets were filled with sand or fine gravel, and in them the mussels were found. The stones, the gravel or sand, and the mussels were all covered with a dense coating of dark green algæ.

All the mussel specimens obtained were small, for large ones can not crowd in among the rocks, and many of the females were gravid. *L. ligamentinus* was the most common species, and every specimen showed clearly the radiating rays on the external surface.

Marginal cysts were found in some of the *S. edentulus* and *L. ligamentinus*, and a few *Atax* in one *L. ventricosus*, but as a whole this lot of mussels was remarkably free from parasites. The number of species at this station was only equalled by those which were obtained from the 15 tons collected at Momence by the mussel fishermen.

Station 32. Wilmington, Ill.—This station was just below the road bridge across the Kankakee River, between the second and third dams. The river here has a rocky bottom and is practically one continuous riffle with a very swift current. There was a large outcrop of limestone on the shore and more appeared in the bed of the river.

The collecting was very difficult, but the few live mussels found were supplemented by a large pile of freshly cleaned shells on the shore, probably left by a pearler. All the shells were large and well developed, particularly the *L. ligamentinus* and *S. costata*. The *L. ventricosus* and *rectus* had an exceptionally good luster and were of excellent quality; the other species were about average.

Station 33. Forked Creek, Wilmington, Ill.—This is a rather small creek that runs into the Kankakee from the north, and is made up of alternating pools and riffles. In the riffles the bottom is rocky, with many gravel and sand bars; in the pools there is more or less mud. The main vegetation is water willows, with occasional yellow water lilies and *Philotria*, and everywhere an abundance of tough algæ. Most of the shells were dead and seemed to have been killed by muskrats. The live specimens of *A. calceola*, *S. edentulus*, and *L. ellipsiformis* were all gravid. The *L. ventricosus* and *ligamentinus* and the *Q. undulata* were all small in size, but otherwise normal.

Station 34, Mazon Creek, Gardner, Ill.—This is another tributary of the Kankakee from the north and in its general features closely resembles Forked Creek. It consists mainly of rather shallow pools connected by slender threads of water, with numerous sand and gravel bars. The bottom is practically all pebbles and sand, with almost no mud. Water willows are thickly distributed, with large patches of spatterdock, but there were not many algæ.

The mussels were found mostly along the edges of the sand bars and were usually small in size. Many of them were actively crawling about and lay at the ends of long furrows. Pearlers had been at work here also, and many recently killed shells were seen along the banks, mostly *Q. undulata*, with some *L. luteolus*. The muskrats were evidently abundant and had left many dead shells scattered along the water's edge, chiefly the small *L. ellipsiformis* and young specimens of *Q. undulata*, *S. complanata*, and *S. edentulus*.

The *L. ellipsiformis* was particularly abundant and an excellent lot was obtained. The young *S. edentulus* and *S. complanata* were all bright-rayed. One *edentulus* and most of the *ellipsiformis* were gravid, and in the former was a single large *Atax ingens*, the only parasite found. The dead shells of *luteolus*, however, looked as if they had been well parasitized and had contained many pearls. One pearl about the size of a small buckshot was obtained from a living specimen, which contained many marginal cysts. This pearl was perfectly spherical, and though fresh, was of rather poor luster.

Station 35. Mouth of the Kankakee River.—The Des Plaines River, which joins the Kankakee to form the Illinois River, is simply an immense sewer bringing down the Chicago drainage. Both rivers, but especially the Des Plaines, are full of the characteristic algæ and other vegetation which grow in such waters, and the combination of a copious vegetation with the sewage has effectually killed off all the mussels in the vicinity. Not a single living specimen could be found in either river, but there were hundreds of dead shells along the banks, most of them old and well bleached, but still capable of identification. The species listed from this station are all such dead shells.

Since this finishes the examination of the Kankakee Basin, it will be well to sum up the general results of the work in the form of brief statements:

SUMMARY OF MUSSEL DISTRIBUTION.

1. The Kankakee River and its two principal tributaries, the Yellow and Iroquois Rivers, present a very rich and varied mussel fauna throughout their entire lengths, except in those portions which have been artificially dredged.

2. The 32 mussel species obtained in the Kankakee Basin produce shells of exceptional size, luster, and quality, and many of them are of high commercial value. (See table, p. 39.)

3. The basin is divided at the State line into two regions, radically different in the conditions which they present, and harboring consequently different mussel faunas. These regions may be designated as the Indiana and Illinois portions of the basin.

4. The Indiana part of the basin is a region of swamps, smooth sandy bottoms, a uniform current, and abundant vegetation. It is the home of *Lampsilis* and *Anodonta*, with relatively few *Quadrula* species. It contains seven species not found in the Illinois part of the basin, viz, *S. compressa*, *A. f. subcylindraceus*, *A. imbecillis*, *L. glans*, *L. iris*, *L. subrostratus*, and *L. parvus*.

5. The Illinois part of the basin is a region of rolling prairie land, rough rocky bottoms, alternating riffles and dead water, with almost no vegetation. It abounds in *Quadrula*, *U. gibbosus*, and *Symphynota*, with comparatively few species of *Lampsilis*. It contains eight species not found in the Indiana part of the basin, viz, *Q. trigona*, *Q. lachrymosa*, *Q. metanevra*, *P. æsopa*, *S. complanata*, *O. ellipsis*, *L. ellipsiformis*, and *L. fallaciosus*.

6. There are seven species universally distributed throughout both regions, viz, *Q. coccinea*, *Q. undulata*, *U. gibbosus*, *A. grandis*, *L. ligamentinus*, *L. luteolus*, and *L. ventricosus*. Five of these possess shells which are in constant demand for the manufacture of buttons, and the table of values given on page 39 shows that they are of exceptionally good quality.

7. Most of the species are richly infested wherever they occur with an interesting variety of parasites, and some of these furnish the requisite incentive for the production of pearls and baroques. Both these products are common throughout the entire basin and would undoubtedly become a valuable revenue if the mussels were properly cultivated. Pearling might not pay here now, as the pearls are quite small. It is, however, the best place the authors have ever seen from which to attack the pearl problem.

8. The most valuable species are all good breeders throughout the basin. This, taken in connection with the excellent quality of the shells they produce and the good railroad facilities everywhere available, makes this basin one of the best yet examined for the supply of glochidia to be used in artificial mussel propagation.

9. The fishes which have proved to be the most satisfactory hosts of glochidia are abundant in all three of the principal rivers of this basin. Their presence insures one of the most essential conditions necessary for the success of mussel culture.

10. The undredged portions of the Yellow River, a distance of 20 miles from Plymouth to Ober, and of the Kankakee, a distance

of at least 100 miles from Riverside to the State line, furnish an ideal breeding ground for the artificial propagation of mussels on a large scale. The swamp reservoirs keep the supply of water uniform, there is just the requisite amount of current, a suitable variety of hard bottom, plenty of lime and natural food in the water, and the region is well protected by its environment from outside molestation and disturbance. For this, as well as many other reasons, it well deserves to be protected from future dredging syndicates.

11. Dredging entirely annihilates the mussel fauna of such a basin throughout the portions operated upon, no matter how prolific and varied that fauna may have been previously. And it establishes artificial conditions, every one of which is antagonistic to any re-establishing of the fauna. The most fatal condition is the constant movement of the fine sand and silt along the bottom of the dredged channels. Until that has ceased there can be no chance for mussels to live.

Portions of the basin which were dredged 15 or 20 years ago show no signs of restocking with mussels, though there are thousands of them close at hand in the old channels.

12. The mussel fauna of the lakes is almost entirely composed of *Anodonta* and *L. luteolus*. With the exception of those found in the Fish Lakes all the lacustrine mussels were practically worthless from a commercial standpoint. The shells were either too thin and brittle or they were dwarfed below a workable size. The excellent quality of those found in the Fish Lakes, however, suggests strongly that under favorable conditions lake mussels may become as valuable as those from a river. The presence in the lake of such a flourishing colony of *Q. undulata* shows that some, at least, of the thick-shelled species can thrive in a lake, a fact experimentally proved for other species by the authors. Why not stock some of the lakes, then, along with the rivers, selecting those species best suited for such conditions?

Station II. Tippecanoe Lake, Kosciusko County, Ind.—This lake does not properly belong to the Kankakee Basin, but drains into the Tippecanoe River and thence into the Wabash. For this reason it has been placed here at the end of the list after the finishing of the Kankakee Basin. The lake lies a little north of the center of the eastern boundary of the county and covers 1.6 square miles, being the fifth largest lake in the State. It is divided into three basins—the eastern, known as James Lake; the central; and the western, called Oswego Lake. Tippecanoe River enters the eastern end of James Basin and flows through the entire length of the lake, maintaining a good current throughout the year. Grassy Creek, the outlet of a chain of four small lakes (Maybe, Sawmill, and the two Barbees) to the south, enters the middle basin near its southwest corner.

The two upper basins are remarkably free from aquatic vegetation, while Oswego basin is packed with *Potamogeton*, *Utricularia*, *Philotria*, and many species of rushes, spatter-dock, water arum, pickerel weed, cat-tails, etc.

The entire lake is surrounded by high and steep banks except in one or two places, and promontories run out into it from both sides. At the southernmost of these promontories on the east side the lake has the remarkable depth of 178 feet, making it probably the deepest fresh-water lake of its size in America. And this is true of the whole lake, the only shallow-water areas of any size being the delta brought in by the Tippecanoe River and a small area along the north side of the east shore. Furthermore, the lake is to-day more nearly in its natural state than any of the others examined. It was a genuine relief to find such a body of water unaffected by damming or draining.

Owing to its great depth, the water is always cool, even in the hottest weather, and is very clear and free from vegetable débris. The bottom is hard and marly in most places except the Oswego Basin, where it is soft black muck. The entire margin of the lake and Tippecanoe River for a mile and a half below the outlet were examined, and mussels were everywhere abundant. At Government Point, over the shallow-water area on the eastern margin already mentioned, they were especially plentiful. Here the marly bottom was softer and the mussels had dug circular cavities 2 or 3 inches deep into the marl. In the bottom of the excavation were sometimes one mussel, sometimes a whole nest of them of varying sizes. *Anodonta*, *Strophitus*, and *Lampsilis* were thus found.

This and other portions of the eastern shore were the only places where *L. glans* and *M. fabale* were found during the entire summer, with one exception for each species.

In the Tippecanoe River the sand and gravel of the swifter current and the marl of the quieter water were found thickly covered everywhere with living mussels and dead shells. *Q. undulata* was the most common species and most of the specimens were exceptionally large and plump. In several of them there was a decided breaking up of the ridges on the outside surface into pustules similar to those on *pustulosa*, making a sort of nondescript shell that was difficult to classify at first.

As would be expected, there were a few species in this fauna not found in the Kankakee Basin. These include *Micromya fabale*, *L. multiradiatus*, *T. sulcata*, and *P. phaseolus*.

The *Quadrulas* have been searched strenuously for pearls and several good ones are reported to have been found, but none of the other species contain either pearls or baroques.

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DISTRIBUTION OF MUSSEL SPECIES.

Mussel species.	Stations.																																										
	1	2	3	4	A	5	6	B	7	8	9	10	11	C	12	13	D	14	15	E	16	F	17	18	19	20	21	G	22	23	24	25	26	27	28	29	30	31	32	33	34	35	H
Quadrula tuberculata (purple warty-back)																															×				×		×	×	×			×	
Quadrula coccinea	×		×	×			×		×	×	×	×	×		×			×	×		×			×	×	×	×		×		×	×			×				×				×
Quadrula trigona (pig-toe)																																		×	×				×				
Quadrula rubiginosa							×		×	×		×	×						×	×			×	×	×				×	×	×	×	×		×		×	×	×	×			×
Quadrula pustulosa (warty-back)							×		×			×	×					×	×		×		×	×	×	×	×		×	×	×	×	×	×	×	×	×	×	×				
Quadrula lachrymosa (maple-leaf)																																×	×	×	×	×	×	×					
Quadrula metanevra (monkey-face)																															×	×			×		×	×				×	
Quadrula undulata (three-ridge)	×		×	×		×	×					×	×				×	×	×		×		×	×	×	×	×		×	×	×	×	×	×	×		×	×	×	×	×		×
Quadrula ebena (niggerhead)																																											×
Pleurobema æsopa (bullhead)																											×				×												
Pleurobema clava																																											×
Unio gibbosus (lady-finger, spike)	×		×	×			×		×	×		×			×		×	×	×		×		×	×	×	×	×		×		×	×	×	×	×	×	×	×	×	×			×
Alasmidonta truncata (elk-toe)									×	×		×																			×	×			×			×	×	×			
Alasmidonta calceola									×		×	×			×																												×
Symphynota complanata (heel-splitter, hatchet-back)																										×			×		×	×		×	×		×	×	×	×	×		
Symphynota costata (squaw-foot)							×		×	×		×	×					×			×				×				×		×	×		×	×		×	×	×	×			
Symphynota compressa							×					×			×	×		×																									
Anodontoides ferussacianus subcylindraceus					×		×					×			×																												
Anodonta grandis	×	×	×	×	×	×	×	×	×			×	×	×	×		×			×		×		×				×	×	×				×	×	×				×		×	×
Anodonta imbecillis						×	×					×	×	×			×		×																								×
Strophitus edentulus	×		×	×			×		×	×		×	×		×			×													×			×				×	×	×	×		×
Obovaria ellipsis (Missouri niggerhead)																															×						×	×					
Lampsilis alatus (pancake)																																						×					
Lampsilis glans																	×																										×
Lampsilis ellipsiformis																															×								×	×	×		
Lampsilis iris							×		×	×		×					×	×																				×					×
Lampsilis subrostratus														×			×																										
Lampsilis rectus (black sand-shell)								×				×					×	×		×		×	×	×	×			×		×	×			×	×	×	×	×					
Lampsilis fallaciosus (slough sand-shell)																																		×									
Lampsilis ligamentinus (mucket)	×		×	×					×		×	×	×					×	×		×		×	×	×				×	×	×	×	×	×	×	×	×	×	×	×		×	
Lampsilis luteolus (fat mucket)	×	×	×	×	×	×	×	×	×	×		×	×	×	×		×	×	×	×	×	×		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Lampsilis ventricosus (pocketbook)	×		×	×			×		×	×	×	×	×		×			×	×		×		×	×	×	×	×		×	×	×	×	×	×	×	×	×	×	×	×			×
Lampsilis multiradiatus																																											×
Micromya fabale																																											×
Truncilla sulcata																																											×
Ptychobranchus phaseolus																																											×

COMMERCIAL VALUE OF THE SHELLS OBTAINED.

The relative values of the mussel shells from the Kankakee Basin were determined by Mr. J. F. Boepple, lately deceased, a mussel expert of wide experience and high authority, then stationed at Fairport, Iowa.

Average lots of the different species were weighed, blanks of various diameters were stamped upon the inside of the shells and counted, the number of similar blanks which could be obtained from a ton of shells was computed, and from these data, together with the quality of the pearl, the value per ton was calculated. In many instances the results of these computations were verified by sending the stamped shells to a button factory, where the blanks were actually sawed out, and their value given.

These values are expressed in the following table, each value quoted being an average from several lots of the same species. The diameter of the blanks is measured in "lines" ($=\frac{1}{40}$ of an inch), 16, 18, etc. "F." and "M." denote first and medium quality. "T." indicates that more than half of the blanks are "tips," that is, uneven in thickness and of poor quality; "t." indicates that considerably less than half are tips. The numerals "1," "2," and "3" indicate different grades of shells, including size, color, luster, etc. Thus, reading the second line, 1 ton of second quality *L. ligamentinus* shells would yield 1,119 gross of 20-line blanks, more than half of which would be "tips." The value of blanks and tips together would be $33.57.

TABLE OF SHELL VALUES.

Locality and species.	Gross of blanks per ton of shells.							Value per ton.
	16 line.	18 line.	20 line.	24 line.	30 line.	35 line.	40 line.	
YELLOW RIVER.								
L. ligamentinus, 1			F. 1,009					$60.54
L. ligamentinus, 2			T. 1,119					33.57
L. ventricosus, 1			M. 833			F. 173		50.94
L. ventricosus, 2				M. 588				23.52
L. luteolus			t. 607					12.14
Q. undulata			T. 573			M. 78		15.09
KANKAKEE IN INDIANA.								
L. ligamentinus, 1			M. 673			F. 104		38.91
L. ligamentinus, 2			t. 1,285					32.15
L. ventricosus, 1			F. 578		F. 347			64.76
L. ventricosus, 2			t. 1,166					29.15
Q. pustulosa, 1		M. 1,297						38.91
Q. pustulosa, 2			t. 809					32.36
Q. pustulosa, 3		t. 1,011						30.33
Q. coccinea, 1		t. 1,255						37.65
Q. coccinea, 2			t. 839					29.45
Q. coccinea, 3		T. 1,404						28.08
IROQUOIS RIVER.								
Q. rubiginosa		t. 1,198						35.70
Q. lachrymosa	t. 1,098					F. 32	F. 34	35.20
KANKAKEE IN ILLINOIS.								
L. ligamentinus, 1			T. 771			F. 111		39.78
L. ligamentinus, 2	T. 1,219	F. 406						24.37
L. ventricosus, 1			T. 1,190					35.70
L. ventricosus, 2			T. 711		F. 278			32.13
L. luteolus	T. 1,994							19.94
Q. pustulosa		t. 1,142						45.68
Q. undulata					F. 119			11.90

SMALL FISHES FOUND ON THE MUSSEL BEDS.

KEY TO TABLE.—I, the undredged portion of the Yellow River from Plymouth to Ober; II, the undredged portion of the Kankakee River from Riverside to the State line; III, the Iroquois River; IV, the Kankakee River in Illinois; V, the lakes.

Species.	I.	II.	III.	IV.	V.
Catostomus commersonii	×	×	......	×	......
Catostomus nigricans	......	×	......	......	×
Schilbeodes gyrinus	×	×	......	......	......
Cottus ictalops	×	......	......	......	......
Lucius lucius	×	×	......	×	......
Lucius reticulatus	×	×	......	......	......
Pimephales notatus	......	×	×	×	×
Semotilus atromaculatus	×	×	×	......	×
Abramis chrysoleucas	×	......	×	......	......
Cliola vigilax	......	......	×	......	......
Fundulus dispar	......	......	......	......	×
Fundulus diaphanus	......	......	......	......	×
Percina caprodes	......	×	......	×	......
Notropis blennius	×	×	×	×	......
Notropis whipplii	×	×	×	×	×
Notropis cornutus	......	×	×	×	×
Notropis umbratilis atripes	......	......	×	×	......
Notropis heterodon	×	×	......	......	×
Ericymba buccata	......	......	×	......	......
Phenacobius mirabilis	......	......	×	......	......
Hybopsis amblops	......	......	×	......	......
Hybopsis kentuckiensis	......	×	......	×	......
Labidesthes sicculus	×	×	×	×	×
Pomoxis annularis	......	......	×	......	......
Perca flavescens	×	......	......	......	×
Microperca punctulata	×	......	......	......	......
Micropterus dolomieu	......	×	×	×	......
Micropterus salmoides	×	×	×	......	×
Chænobryttus gulosus	×	......	......	......	×
Ambloplites rupestris	×	×	......	×	×
Lepomis pallidus	......	×	......	......	×
Eupomotis gibbosus	......	×	......	......	×
Hadropterus phoxocephalus	......	......	×	×	......
Hadropterus aspro	×	×	×	×	......
Boleosoma nigrum	×	×	×	×	×
Etheostoma cœruleum	......	......	×	×	......
Etheostoma iowæ	×	......	......	......	×
Maxostoma aureolum	......	×	......	......	......

DISCUSSION OF MUSSEL SPECIES.

1. *Quadrula tuberculata* (*Rafinesque*). *Purple warty-back.*—This mussel, although it attains considerable size and weight, rivaling or exceeding the common warty-back (*Q. pustulosa*) in this respect, is of no value whatever to the button industry on account of the dull purple nacre. It nowhere forms large beds and wherever found usually constitutes a small per cent of the mussel fauna.

Of all the heavy-shelled species examined anywhere, however, this is the most liable to infection by distomids, perhaps on account of its immense inhalent aperture, which allows a larger and greater variety of objects to enter than is the case of other strong-shelled mussels. This makes it among the greatest producers of dorsal baroques and, generally speaking, it is the species most likely to produce genuine pearls. The baroques may be either purple or pale, almost white, and generally are rather lusterless and of low value. The pearls are always purple, sometimes almost black, and, when formed near the iridescent tip of the mussel, may have a very good luster. The clammer cleans all shells he obtains, whether valuable for buttons or not, in the hope of finding pearls.

Viewed in this light, *Q. tuberculata* is not altogether unimportant as a commercial species. Its shell is the package that may contain a prize—usually a worthless trinket, but always arousing expectancy. *Q. tuberculata* adds more markedly than any other species to the size, but hardly to the value, of the clammer's pile of slugs or "chicken feed" which furnishes, in some cases a small, in others a considerable addition to the revenue derived from the sale of his shells, and it is indeed one of the strongest incentives to persistence in the clammer's trade, as it furnishes not so much in actual cash as the element of luck or chance, and keeps him in constant expectancy of a possible great discovery.

Accordingly, it is not improbable that clamming operations the country over depend in no inconsiderable degree on the presence of this and similar species, not directly useful of themselves, but appealing to the instincts of the treasure seeker, the nomad, and adventurer, who can not endure the monotony of a steady, uneventful trade and who require some special incentive or stimulus to persistency.

This species is of value as furnishing in almost any part of the country readily available material for the study of the natural causes and phenomena of pearl production and will probably prove in the end one of the gateways through which our knowledge in that direction, and its practical applications, will come.

We did not find this species in the headwaters of the Kankakee or Yellow Rivers, though it is common in the Tippecanoe, not far distant. The first found in the Kankakee was at Momence, Ill., and in the lower stretches of the river. It was also found in the Iroquois.

The systematic position of this species is doubtful. We have never found it gravid, and it is, apparently, but rarely found in that condition. It is reported to bear glochidia in only the outer gills. When ground and polished for ornament, this is one of the most attractive of shells.

2. Quadrula ebena (Lea). Niggerhead.—This, the most valuable of button shells, does not occur within the Kankakee Basin, though it is fairly common in parts of the Illinois River, below. We found one specimen of what appeared to be this shell at Tippecanoe Lake, where its occurrence is difficult to account for.

3. Quadrula coccinea (Conrad).—*Q. coccinea* is, at its best, a very good, if not excellent, button shell. The assemblage of forms that pass under this name exhibit so much variation, however, that no general statement can be made concerning it. It has no trade name, probably because it has not been found in great quantities in regions exploited by the button industry and partly because of its lack of distinctive characters. But it is found throughout the length of the Kankakee and Yellow River systems wherever shells thrive at all, being represented by specimens in 22 of the 35 river stations

investigated. It occurs occasionally in lakes, but is essentially a river shell. A few were found in Tippecanoe Lake.

In the upper parts of the Yellow River, from Plymouth down to Ober, and in places in the upper Kankakee this species reaches great perfection and is represented by a well-defined type not easily confused with any other species—a large flat shell of pretty uniform thickness and very good luster. The majority of the shells of the upper part of the river are of a delicate pink color, very pleasing to the ordinary eye, but not to the maker of buttons. Farther down stream the majority are white-nacred and serviceable in the commercial sense. We were unable to obtain any gravid specimens of this flat, highly characteristic form. *Q. coccinea* was fairly common in the clammer's pile at Momence.

In some of the lower parts of the Kankakee system, and especially in the Iroquois River, what appears to be this species loses its distinctive character and is represented by a much more inflated form, closely approaching *Quadrula solida* or some other member of the perplexing *obliqua-trigona-plena-solida* group. A gravid specimen of this inflated form was obtained in the Iroquois River. Only the outer gills contained the glochidia. These filled the entire gill, which was padlike and white in color. According to Simpson's classification this would place it in the genus *Pleurobema*, but more examples are desired and the whole subject requires investigation. Dr. A. E. Ortmann is of the opinion that *Q. coccinea* is identical with *Q. obliqua*, which usually bears its glochidia in only two gills and which he considers a *Pleurobema.* All the examples of *Q. coccinea* we have ever seen, however, even the inflated ones, have lacked the peculiar sulcus that is to be found in *Q. obliqua.*

4. Quadrula trigona (Lea). Pig-toe.—This species is one of the staple button shells. Its size is usually rather small, and a furrow on the valve makes it difficult to cut to advantage, but its excellent luster and whiteness compensate to some extent for its deficiencies and it is excellent for small buttons. Its occurrence in the Kankakee area is exceptional; one was found in the Iroquois at L'Erable and one in that stream 3 miles above its mouth. Another was found in the Kankakee at Wilmington. These are not exactly typical shells. It is somewhat surprising that it is not more common, as it could easily come up from the Illinois River.

In the upper Mississippi, where the species is abundant, it is very constant in form, and well marked from any other species, but outside of this range it is quite variable in form. It is very frequently infested by a distomid which forms cysts in the mantle, and it occasionally produces beautiful pearls.

5. Quadrula rubiginosa (Lea).—This shell is quite similar to *Q. coccinea*, from which it is somewhat difficult to separate it. It

is usually a smaller shell and has a more distinct posterior ridge, which is the chief distinguishing characteristic. The nacre is never pink, but may in rare instances have a yellowish cast. The species has about the same value for buttons as *Q. coccinea.* In the button makers' category it would be classed with the pig-toe group, but it has received no regular trade name.

Q. rubiginosa was found almost the entire length of the Yellow and Kankakee Basins, but was more common in the lower river. It was common in the clammer's shell pile at Momence and in the Iroquois. It is one of the few *Quadrulas* found fairly common in the lakes. We found it in both Tippecanoe and Koontz Lakes. In lakes it is represented by a peculiar dwarfed form with a satiny epidermis. It was difficult to distinguish between the peculiar inflated form found at L'Erable and *trigona.* Some of these were gravid, all four gills being filled, and of a reddish color. The flesh of some of the examples was white, of others reddish. Distomid cysts were very abundant in the margins of the mantle.

6. Quadrula pustulosa (*Lea*). *Warty-back.*—This is a well-known shell among the clammers and button cutters. It is exceedingly variable, sometimes being small and much inflated, and at other places flattish. In some localities it is exceedingly rough and warty and in other places almost smooth. It therefore varies considerably in value, the flatter shells being of more value than the inflated and the smooth better than the rough. In the Kankakee Basin this species has about the same distribution as *Q. rubiginosa*, but is never found in lakes, and is more common in the lower stretches of the river. The examples obtained at Nickelplate were unusually flattish; those about Momence had some of the tubercles developed into long ribs elongate along the lines of growth. It was common in the clammer's pile at Momence and at the pearler's camp below Momence. It was also found in the Iroquois at Watseka and L'Erable.

7. Quadrula lachrymosa (*Lea*). *Maple-leaf.*—This is a well-known shell among button manufacturers, hardly so much on account of its excellence as of the fact that it occurs in considerable abundance in regions where clamming is carried on and the shells can be made good use of. In quality they are about the same as *Q. pustulosa*, the warty-back, but the sulcus or groove along the middle of the shell prevents it from being used to so good an advantage.

In the Kankakee Basin this species is found only in the lower stretches of the Kankakee River and in the Iroquois, and then only in small numbers. At L'Erable on the Iroquois (Aug. 21) they were beginning to become gravid.

8. Quadrula metanevra (*Rafinesque*). *Monkey-face.*—This species, which has about the same commercial value as the preceding, was

found only in the lower stretches of the Kankakee. The first we saw were in the clammer's pile at Momence, where it was fairly common. A few were found in the mouth of the Kankakee.

9. Quadrula undulata (Barnes). Three-ridge.—Two closely related shells, *Q. undulata* and *Q. plicata*, are known to the shell trade as "three-ridge" and "blue-point," both names being applied indiscriminately to either species. The extreme forms of these two species are well marked and easily recognizable, and where this is the case it is better to apply the term "three-ridge" to *Q. undulata* and "blue-point" to the other shell. Generally, one does not find well-marked examples of both species in the same stream; where the well-marked flatter form (*Q. undulata*) is common, the fuller form (*Q. plicata*) is usually, if not always, absent. All the shells in the Feeder Canal, at Fort Wayne, Ind., seem to be *Q. undulata*, and all noted from the Illinois River seem to be *Q. plicata.* The shells of White River, Ind., seem to be intermediate.

Q. plicata is a fairly valuable button shell and is usually regarded among pearl hunters as a fruitful source of pearls. *Q. undulata*, on account of its thinness, is not quite so valuable as *plicata.* It is a variable shell and differs considerably in value, according to which of its many forms is encountered. The *Q. undulata* of the Kankakee is of low value on account of its roughness and the great depth of its furrows, which interfere with cutting and polishing. It was found abundantly and quite large in Fish Lake, as well as throughout the course of the Yellow and Kankakee Rivers, where it was one of the most widely distributed shells. It was fairly common in the Iroquois as well as in the Yellow and Kankakee and was found in Mazon Creek near Gardiner, Ill. In the old Kankakee Channel at the Nickel Plate Railroad bridge, also at Davis, Ind., and at Kouts and Burton's camp it was the most abundant shell. At Peterson's camp we found some with a yellow epidermis, and at Tippecanoe Lake (July 28) we obtained three gravid examples.

10. Pleurobema œsopa (Green). Bullhead.—The bullhead is a well-known shell among button manufacturers. Its quality and value differ considerably in different rivers, but it is always a rather inferior shell on account of its brittleness, and in some of the southern rivers it is so hard and flinty that it breaks the teeth out of the saws and the button cutters do not attempt to cut it at all. Among the clammers of the Cumberland it is known as the "clear profit," as the clammer is the only one who gets anything out of it.

In the Kankakee this is a very rare shell. The only ones we saw during the entire trip were three in the clammer's pile at Momence and one at Water Valley.

11. Pleurobema clava (Lamarck).—This is a handsome shell, too small to be of any use in the manufacture of buttons. It does not

occur at all in the Kankakee Basin, but is common in the Tippecanoe River. We found a few in Tippecanoe Lake.

12. Unio gibbosus (Barnes). Lady-finger, spike.—Unio gibbosus is a common, widely distributed shell, found in all sorts of situations; being one of the common shells of lakes, as well as rivers. The nacre is usually a rather dull purple, which unfits it for the button industry. A white-nacred form is not altogether uncommon. It has a soft satiny luster and can be used commercially. The shells vary in form as well as in color, some being short and humped, more or less closely resembling *P. phaseolus*, and others long and sharp, and at times difficult to separate from *L. rectus*.

U. gibbosus was one of the most widely distributed shells within the Kankakee Basin, being found at nearly all the stations in the Yellow and Kankakee as well as in the Iroquois and in Fish Lake. It was also found in Tippecanoe Lake. It formed most of the culls in the pearler's pile at Momence.

Marginal cysts caused by distomids, dorsal baroques, and small round pearls are common in this species.

One white-nacred shell was found at Plymouth, but as a rule all the shells of the upper parts of the river were deep purple. At Momence these shells exhibited peculiar and interesting phenomena. They seemed to be passing here from the purple-nacred form to the white, and one had all intermediate stages; many were of a beautiful rosy hue throughout, others shaded from blue about the margin through rosy to pale rose. Investigations on other streams have shown similar peculiarities of the color distribution in this shell.

It is worthy of note that both *U. gibbosus* and *L. rectus* become more nearly, or a greater per cent, white-nacred as we go down the Kankakee system, and a careful study here may throw light on the cause of the color in these shells. It may be that the softer waters and amount of humic acid in the upper waters may favor the purplish deposit, while the colorless forms which occur shortly after the limestone river bed is reached may be favored by an excess or abundance of lime.

13. Alasmidonta truncata (B.H. Wright). Elk-toe.—Alasmidonta truncata is a handsome, beautifully rayed shell, attractive to the collector, but too thin to be of any service in the manufacture of buttons. It is not common in the Kankakee Basin. There was a fair number of shells in the clammer's shell pile at Momence and a few were collected at the mouth of the Iroquois River.

14. Alasmidonta calceola (Lea).—This shell is too small to have any commercial value. It is a shell of small streams, and is occasionally found in lakes. It was quite common in the Yellow River at Plymouth and some examples there reached a very large size for the species. It was found at Forked Creek, near Wilmington, and was there noted as becoming gravid (Aug. 27).

15. Symphynota complanata (*Barnes*). *Heel-splitter, hatchet-back.*—At its very best, this species, offering a broad, flat expanse of satiny white nacre, is an excellent button shell, furnishing more blanks per shell than any other species. In many cases, however, it is too thin for use. This species is found only in the lower half of the river; the first seen were at Hebron Bridge, where we found three. In the clammer's shell pile at Momence it was common and large. It was also found at the mouth of the Iroquois, some fine ones were seen at Kankakee, Ill., and a few at Wilmington. Small ones, cleaned out by muskrats, were found in Mazon Creek.

16. Symphynota costata (*Rafinesque*). *Squaw-foot.*—This species is rarely used for buttons, the nacre being too yellow, and frequently too thin. It is well distributed throughout both the Yellow and Kankakee Rivers, and is fairly common at Plymouth below the dam; 26 were obtained there in a shell pile left by pearlers. In the clammer's pile at Momence it was common and large, although not so immense and thick as found in some rivers. It was also found in the Iroquois River at L'Erable. This species in some rivers is especially subject to distomid infection and occasionally bears pearls.

17. Symphynota compressa (*Lea*).—Compared with the *Symphynotas* just mentioned, this is a small shell. It is always too thin to have any commercial value. It was found in the Yellow River from Plymouth just below the dam to the Zinc Bridge at Ober, in Potato Creek at Walkerton, in Yellowbanks Creek, and the Kankakee at Davis. It is a species belonging to small streams. It was beginning to be gravid at Plymouth September 20, with the embryos orange red, in the outer gills of the parent.

18. Anodontoides ferussacianus (*Lea*).—This is a small thin shell of no economic importance. Like *Symphynota compressa* it is usually confined to small streams, and occasionally lakes. It was rather common at Plymouth; one was found dead in Lake of the Woods, and a few in Yellowbanks Creek. The form found in this area appears to be the subspecies *subcylindraceus.*

19. Anodonta grandis (*Say*).—This species, although it reaches large size, is usually thin-shelled, and only exceptionally attains sufficient thickness to have any commercial value. It was found at the majority of stations throughout the Yellow and Kankakee Rivers, and in the Iroquois. In the lakes (except Fish Lakes, where the river form occurred) this species was represented by a dwarfed somewhat inflated form, the variety *footiana.* Particular attention was paid to the shells above the dam at Plymouth, where the water had been pond-like or lake-like for many years, to observe whether the shells were beginning to approximate in appearance the dwarfed form of the neighboring lakes; but they were all the large, elongate river form.

Anodontas are always more subject to attacks of parasites than any other of our fresh-water mussels, and those of the Kankakee Basin were no exceptions to this rule. Common among the parasites is a distomid which usually is found on the surface of the mantle in the dorsal region of the mussel next to the hinge and causing the nacre to become brick red in color. As this distomid has never received a scientific name, the adult form being up to the present unknown, in our reference to it we have spoken of this form as the distomid of Osborn, after its discoverer. Others of the infected shells were of a dark chocolate color and the distomids, which were plentiful, were smaller in size and probably belonged to a different species.

Other parasites frequently found were *Aspidogaster conchicola* in the pericardial cavity, *Cotylaspis insignis* in the axils of the gills, and numerous species of *Atax* inhabiting the branchial cavity. All the *Anodontas* found in the streams corresponded pretty closely to one type, in no case departing so far as to raise any doubts as to identity; in the lakes, however, it was different; each lake seemed to have a more or less pronounced type of its own. The *Anodontas* of Twin Lakes resemble those of Bass Lake and Cedar Lake pretty closely, but those of Lake of the Woods differ considerably, being larger and thinner. At Tippecanoe Lake, where the dead *Anodonta* shells were so abundant that in places we would frequently find them nested sometimes three in a nest, they presented a different, more inflated type. They very closely, indeed, approached the form known as *Anodonta corpulenta*, generally considered a distinct species from *grandis*. We also found two broken dead shells at Tippecanoe Lake which very closely resembled *A. suborbiculata*, and may, indeed, have been that species; more material would be desirable before deciding.

The *Anodontas* from one of the Twin Lakes, as has already been remarked, were infected in great numbers by a distomid forming clear spherical cysts in the margin of the mantle. Sporocysts and peculiar large white areas like blisters were common on the *Anodontas* of Tippecanoe Lake.

20. Anodonta imbecillis (*Say*).—This dainty, fragile *Anodonta* is of no commercial value. It is a shell of ponds and small streams. The only shell found in Millpond Lake of the Twin Lakes was one example of this species. In the Yellow River at Plymouth below the dam it was fairly common. On July 14 several were obtained here, all gravid, the entire outer gills being thick and padlike, and, when the gills were fully ripe, dark brown. The glochidia have a brown shell, shield-shaped in profile, and have long, coiled threads. One found in Tippecanoe Lake was unusually elongate. A large one was found in the Yellow River at Zinc Bridge, another was found in the outlet of Fish Lakes, and a gravid example was found in the Kankakee bed at Davis (Aug. 9).

21. Strophitus edentulus (*Say*).—This is an exceedingly variable shell, considerably resembling an *Anodonta*, and in none of its forms of any commercial importance. It is found in a great variety of situations, in lakes and ponds and both in rather small creeks and large rivers. It is never found in great abundance anywhere. In the Kankakee Basin we found only a few, but these were widely distributed. A dead shell was found at the first station made, on the banks of the Yellow River at Bremen. Some were found at the pearler's pile below the dam at Plymouth, some in Tippecanoe Lake, dwarfed and mostly dead, one valve in the old bed of the Kankakee at Davis, Ind., two at Momence, one at Custer Park with distomid cysts, some at Wilmington, and a gravid example in Forked Creek (Aug. 27). In Mazon Creek at Gardiner, Ill., occurred a brightly rayed form, *pavonia*.

The question of rays appears to be closely related to clearness of water; in turbid streams mussels are usually dull colored, while in clear streams they are usually more brightly rayed.

22. Ptychobranchus phaseolus (*Hildreth*). *Kidney-shell.*—This species, which at its best is a very good button shell, having a white nacre of soft satiny luster, was found only in Tippecanoe Lake. It is also fairly common in the Tippecanoe River, but was not found in the Kankakee River or any of its tributaries.

23. Obovaria ellipsis (*Lea*). *Missouri niggerhead.*—This is a first-class button shell and well known among clammers and button manufacturers. It is of rare occurrence in the Kankakee. We saw it only at the clammer's shell pile at Momence.

24. Lampsilis alatus (*Say*). *Pancake.*—This shell, on account of its thinness and purple color, is of no value to the button trade. It is rare in the Kankakee. We found only one decayed dead shell above Nickel Plate crossing and another dead shell at Custer Park.

25. Lampsilis glans (*Lea*).—This is a shell of lakes and small streams. Its small size and purple color prevent its being of any commercial value. *L. glans* was found only at Plymouth below the dam and in Tippecanoe Lake. At Plymouth it was found gravid (July 27). The glochidia were in a kidney-shaped mass in the posterior part of the outer gill, and are apron-shaped in outline, as is usual in *Lampsilis*. The edge of the gravid portion of the gill has a deposition of black pigment, as in *L. ventricosus* and related forms.

26. Lampsilis ellipsiformis (*Conrad*).—This small shell (too small to be of any value commercially) was found only in the lower part of the river and in the tributary streams. The first we saw were in the clammer's pile at Momence, where it was fairly common. We got 20 there. It was also common in Forked Creek near Wilmington, where all but one were gravid (Aug. 27). Shells opened by muskrats were quite common in Mazon Creek near Gardiner, Ill.

27. Lampsilis iris (*Lea*).—This very pretty shell is of no commercial importance on account of its small size. It was fairly common and reached an unusual size in the stretch of Yellow River from Plymouth to below Burr Oak. Two were obtained in Tippecanoe Lake, one of them gravid (July 28). A gravid one was obtained above Zinc Bridge (Aug. 3). One was found dead in the Kankakee at Davis, Ind.

28. Lampsilis subrostratus (*Say*).—This shell, like *L. iris*, which it in some respects resembles, is too small to have any commercial value. Although occasionally occurring in rivers, it is essentially a lake or slough shell. All we obtained within the Kankakee Basin were found in lakes. Four were obtained in Twin Lakes (July 2), of which one was gravid, the young being contained in a kidney or bean shaped mass in the posterior part of the outer gill, the mass being deeply ribbed, dusky near the margin, and white along the very margin. Some were obtained in Tippecanoe Lake and some in Fish Lake, where it was fairly common. Fragments were found at Round Lake, a small lake near Knox, Ind.

29. Lampsilis rectus (*Lamarck*). *Black sand-shell.*—This species, when it has white nacre, as it sometimes does, is an excellent shell for both buttons and knife handles, approaching in value the yellow sand shell. In some rivers the majority of shells are white, in others colored. This shell is rare in Yellow River. Some were found at the pearler's pile below the dam at Plymouth, Ind., and in 1906 a few were found at Knox. A few were found also in the Kankakee above Nickel Plate crossing, some at Davis, and near Kouts and Hebron Bridge. It was not common in the clammer's pile at Momence, and some young shells were found at Wilmington. It was also in the Iroquois at L'Erable and at the mouth.

The shells of the upper portion of the Kankakee were all colored, some of them a deep purple. Lower down this color faded to a pink. In a pearler's pile at Momence we found the first white-nacred one. The color of this shell seems to be about the same as that of *U. gibbosus* and seems to respond to the same conditions. It is not, however, distributed the same in the shell, but seems to be most marked in the umbonal cavity or teeth. Shells of *L. rectus* which are perfectly white otherwise often are pink or amethystine purple on the teeth or umbonal cavity. The rosy hue of *Q. coccinea* seems to be of a somewhat different nature and notably differs as one proceeds down the river.

30. Lampsilis fallaciosus (*Smith*). *Slough sand-shell.*—This species, valuable for small buttons, is rare in the Kankakee Basin. The only ones found were in the Iroquois River at L'Erable. Most of these contained distomid cysts in the margin of the mantle.

31. Lampsilis ligamentinus (*Lamarck*). *Mucket.*—The mucket is one of the best known of the button shells, and probably more tons of

this species are used in the button-making industry than any other single species. It is not so good a shell as the niggerhead and a few others, but is one of the commonest and most widely distributed and the material is very good.

This species is not found in lakes and is not common in the smaller streams. It occurs throughout the length of the Yellow and Kankakee Rivers, but is rather scattered in the Yellow and upper Kankakee. In the lower Kankakee it is found at every station, and began markedly increasing in numbers about Sheldon, Ind. It formed the main mass of shells in the pearler's pile at Momence, Ill., and fine examples were seen in a pile of shells left by a pearler below Momence. It was also found in considerable numbers at Custer Park, Wilmington, and at the mouth of the Kankakee. In the Iroquois River it was found at L'Erable and near the mouth. A large number were gravid at Momence, August 23.

32. Lampsilis luteolus (*Lamarck*). *Fat mucket.*—*Lampsilis luteolus* is a quite variable shell. It is inferior to the mucket on account of being smaller and more cylindrical, and the greater curvature of the valves makes it harder to work up satisfactorily. Such large fine specimens as occur in some rivers, e. g., the St. Joseph River at Fort Wayne, Ind., would make excellent buttons, but these are not common.

It is one of the most abundant and widely distributed shells and is usually found in lakes and in small rivers. In the Kankakee Basin it occurred at almost every station, in lakes, rivers, and streams alike.

In parts of the Kankakee Basin this species is of especial interest, as many of the examples found are infested with a parasite which leads to the formation of perfect spherical pearls. The pearls are all of small size and on this account not of enough value to justify working them. They are, however, of great scientific interest, as they offer unusual opportunities for the study of pearl formation. In places a single mussel will contain as many as a half dozen or more pearls, and the average will run more than a pearl per mussel. A lot of material was collected which furnished fine sections showing the epithelial sac in which pearls are formed. It also indicated the cause of pearl formation to be probably a small distomid which formed cysts in the mantle of the mussels. It was greatly hoped that opportunities would be given to follow up this subject further, but this hope has not been realized. This field offers excellent opportunities to the investigator.

33. Lampsilis multiradiatus (*Lea*).—This very pretty, much-rayed shell resembles *Lampsilis ventricosus* in general form, but is too small and thin to be of any service in the manufacture of buttons. It was not found in the Kankakee Basin at all, but was not rare in Tippecanoe Lake and River.

34. Lampsilis ventricosus (Barnes). Pocketbook.—Lampsilis ventricosus is a widely distributed and exceedingly variable shell, occurring in both lakes and streams. Its commercial value varies greatly in different situations. In some locations it is too thin to be of any value whatever. The nacre is usually white and of good luster, though pink or reddish ones are occasionally found.

In the Yellow and Kankakee Rivers this species reaches unusual size and thickness; indeed, in 1906 was obtained, in the Yellow River near Plymouth, what at that time was the record shell for this species, exceeding in size any in the National Museum collection. In the active collecting that has been going on since, it is possible, of course, that larger shells have been found. It was fairly abundant in the Yellow River below Plymouth and became more common in the Kankakee, until below Burton's camp it was present at every station. We did not find it in the Iroquois or in any of the lakes within the Kankakee Basin, though it is fairly common in Lake Maxinkuckee. The form found in the Yellow and Kankakee is the large oval form, either plain or, in some cases, beautifully rayed (*occidens*); near the city of Kankakee, Ill., however, we obtained some specimens with a pretty well-marked posterior ridge (*subovatus*). It was represented by numerous large shells in the clammer's camp at Momence. They were found becoming gravid at Plymouth July 15, spawning in the Tippecanoe River July 28, gravid at Zinc Bridge August 4, and at Custer Park August 27. In Yellow River this species bears numerous small dorsal baroques.

35. Micromya fabale (Lea).—This dainty little shell was found at Tippecanoe Lake and is fairly common in the Tippecanoe River, but was not found in the Kankakee Basin. It has no commercial value.

36. Truncilla sulcata (Lea).—This little shell was found at Tippecanoe Lake, but was absent from the Kankakee Basin. It is interesting as the representative of the most highly differentiated genus of mussels, a genus mostly southern in distribution. It has no commercial value.

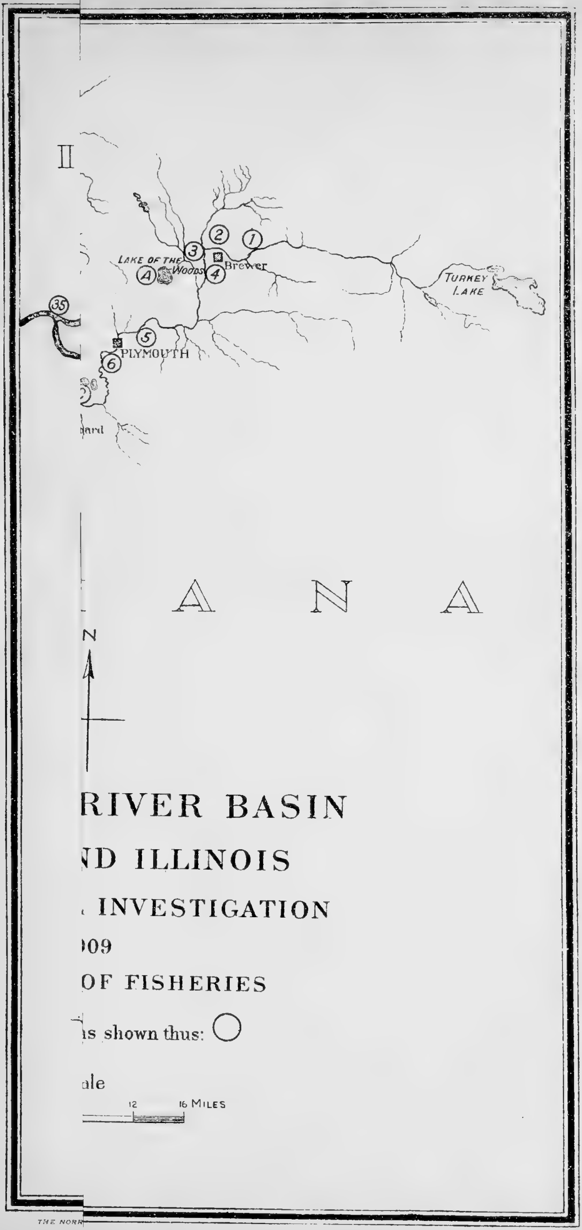
ECONOMIC CONSIDERATIONS.

Although the upper portion of the Yellow River is fairly well populated with mussels, it is a small stream and the distance is short, so that commerical operations would soon deplete it. It is, however, a region of especially large and fine *L. ventricosus.* Many of the finest shells of this part of the river have been killed by pearlers, and to gather up and market the cleaned shells might be worth while to some resident of the vicinity. It would hardly be profitable for a professional clammer to construct gear and work this region. Whether it would be a good plan to procure spawn of the remarkably fine *ventricosus* found here for planting elsewhere can not be deter-

mined until it is known that their excellence was hereditary rather than produced by exceptionally favorable conditions.

The dredged portion of the Yellow River, extending from Ober to its mouth, and the dredged part of the Kankakee, so far as the bottom is still unsettled, extending from its source to below the Hebron Bridge, would be hardly workable, for though there is a fair number of mussels, these are all in the old bed, which lies now on this, now on that, side of the main navigable channel in the form of crescent-shaped bayous, in many cases extending miles back from the present (artificial) channel. Even in this new channel clamming operations would be neither wise nor profitable until the mussel fauna becomes more firmly established. The clammers at Momence worked upstream as far as they found it profitable, and were getting ready to leave for more promising regions at the time of our visit.

The most profitable region commercially is the stretch of river between Momence and Wilmington, Ill., and this is now (1911) being exploited. A shell dealer of Muscatine (Mr. W. S. Berry) furnished the information (October, 1911) that between Waldron and the Kankakee Dam ($5\frac{1}{2}$ miles by water) he had obtained nine carloads of shells, and three below Kankakee, 90 per cent of which were muckets, with a few razorbacks, three-ridges, and big pink pocketbooks. The three-ridges were of little value on account of the deep furrows between the ridges. Below the Kankakee Bridge 200 tons were obtained within 1,000 yards by means of the fork.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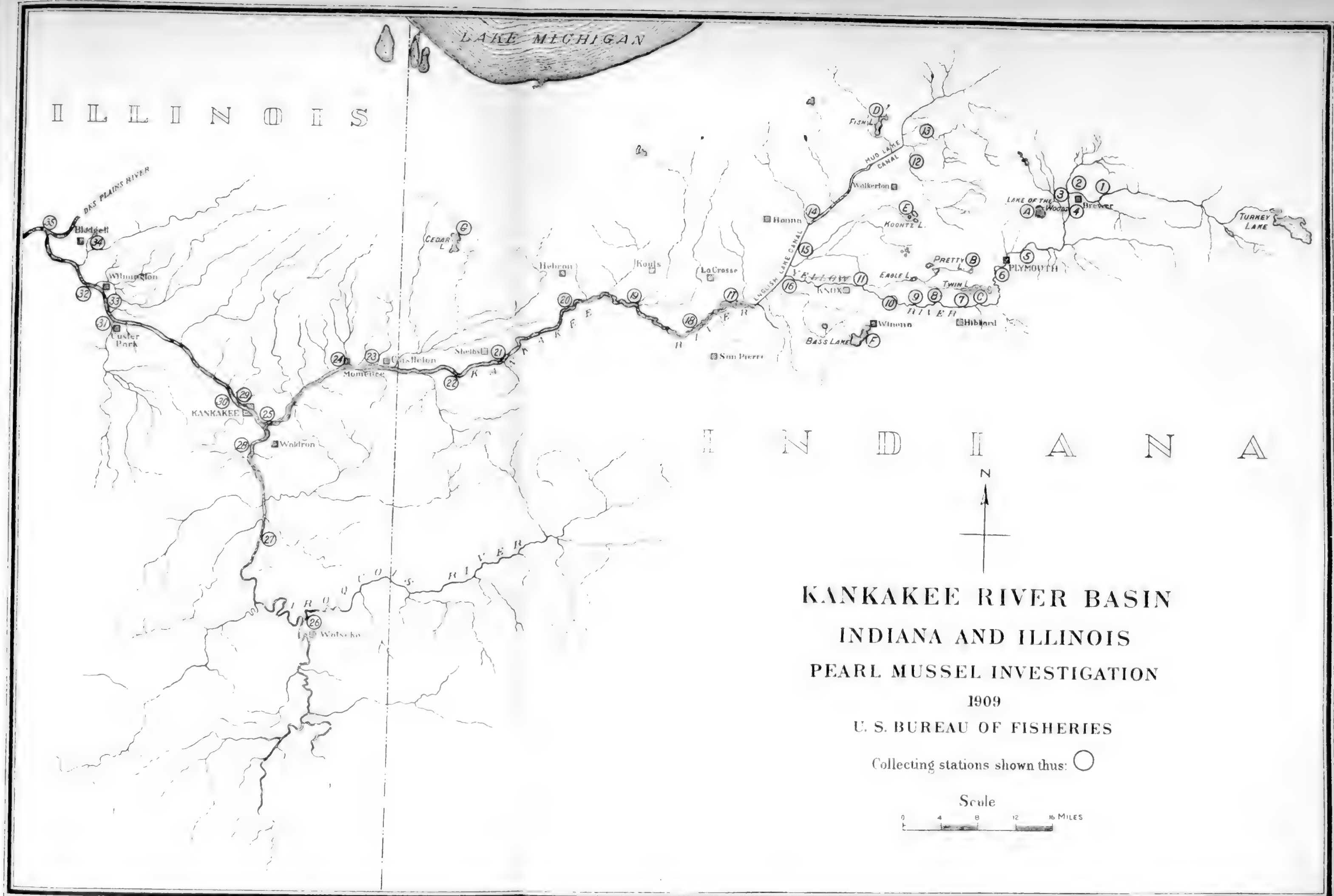

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Blodgett
Wilmington
Custer Park
KANKAKEE
Waldron
Momence
Castleton
Shelby
Hebron
Kouts
La Crosse
San Pierre
Hanna
Walkerton
KNOX
Winona
Bass Lake
Hibbard
PLYMOUTH
Brewer
Lake of the Woods
Turkey Lake
Fish L.
Cedar L.
Koontz L.
Pretty L.
Eagle L.
Twin L.
Mud Lake Canal
English Lake Canal
Yellow River
Kankakee River
Iroquois River
Watseka
N
KANKAKEE RIVER BASIN
INDIANA AND ILLINOIS
PEARL MUSSEL INVESTIGATION
1909
U. S. BUREAU OF FISHERIES
Collecting stations shown thus: ○
Scale
0 4 8 12 16 Miles

THE MUSSELS OF THE BIG BUFFALO FORK OF WHITE RIVER, ARKANSAS

By S. E. MEEK and H. WALTON CLARK

Bureau of Fisheries Document No. 759

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PHYSICAL AND BIOLOGICAL CONDITIONS.

The Big Buffalo River drains a considerable portion of the northern slope of the Boston Mountains. It is a winding stream bordered on its outer curves by bluffs, most of which rise perpendicularly from the water to a height of 20 to 400 feet or more. In many places back from these bluffs the highest mountains rise quite abruptly to a height of about 1,500 feet above the river. The immediate banks were estimated to be from 10 to 30 feet high. In many places where a root hold can be had on the face of these bluffs stunted cedars are growing, and these become more numerous and taller along its upper margin. The slopes and tops of the mountains support a considerable forest of oak and pine. The river valley is narrow, which is also true of all its tributaries. In dry weather the river is little more than a creek, and such it is usually called by the residents; but in wet weather it often becomes a raging mountain torrent. In its lower course it has been known to rise 30 feet or more in one day.

Prof. W. N. Gladson, of the University of Arkansas, to whom the party was indebted for many courtesies, examined the river for mussels between Boxley and a point about 10 miles above the ford on the road from Harrison to Jasper. No shells were found in this portion of the river except a few in the last mile or two.

The bed of the portion of the stream visited varied in width from about 30 feet to 200 feet. Over many shoals the water was not deep enough to float the boats, which drew only about 5 inches of water, and in the long, deep holes it seldom exceeded a depth of 6 feet. Along the course of the river are many sand and gravel bars, which seem to shift more or less with each freshet, leaving, perhaps, less than half the river in anything like a permanent bed.

Mussel beds, as compared with those on the White River, were neither large nor plentiful, and these occupied only the favorable

places in the bed of the stream which appeared to be permanent. No beds were found on sand bars, and when found on gravel bars the sand and gravel were mixed with larger fragments of rocks. It would be quite impossible to collect shells in this stream with tongs or drags such as are successfully used on the Illinois River in Illinois. Nowhere were shells found in abundance, and if all shells taken out by the pearl hunters could be used in the manufacture of buttons there could certainly not be much profit in collecting and transporting them.

Notwithstanding the statements of some pearl hunters that a bed can be worked thoroughly one season and as many shells found there the following one, the general impression is that the mussels are not so abundant as formerly. During the low water the hogs eat all that they are able to obtain, and are, no doubt, partially responsible for the depletion of many beds in the upper course of the stream. Inquiries were made as to shells in the smaller tributaries, and the answer was either " none " or " very few." Along the portion of the river examined the beds have all been very thoroughly worked annually for the past few years by pearl hunters, and work of this nature was being carried on energetically in 1910.

It seems that a stream which varies so greatly in volume as this one does, so much of its bed changed by freshets, with scarcely any permanent sand bars, would not furnish conditions for an abundant growth of mussels. Between Boxley and a point about 10 miles above the ford on the Harrison-Jasper road only one small bed was observed.

The distance between our first and last camps was 95.8 miles, and the difference in elevation was 402 feet, or about 4.2 feet per mile. The fall for the first 15 miles was about 4.3 feet per mile, and in the last 15 miles 3.2 feet per mile. Between our camps of July 28 and July 30 the fall was 4.9 feet per mile for a distance of about 15 miles.

During the trip the river was gauged at three places with the following results: The flow of Buffalo River above the forks of Little Buffalo, sec. 8, T. 16 N., R. 20 W., on July 22 was 43.6 cubic feet per second, the gauge height at Gilbert on this day being 3.6 feet; the width of water was 54 feet. On July 26, in sec. 35, T. 16 N., R. 20 W., below the forks the flow was 85.19 cubic feet per second, with a gauge height at Gilbert of 3.8; width 64 feet. On August 1 at Gilbert the flow was 137.4 cubic feet per second, gauge 3.2, width 68.

The following is a list of camps, giving the elevation of each and the distance from each to the next as furnished by Prof. Gladson. The measurements are stadia distances in feet between each station and the following one. The elevations are above mean sea level, Gulf of Mexico, from United States Geological Survey bench marks, Fayetteville, Ark.

CAMPS ON BUFFALO FORK OF WHITE RIVER, ARK.

Camp designation.	Location.	Elevation.	Stadia distance from preceding station.
	NEWTON COUNTY, ARK.	*Feet.*	*Feet.*
A	South line of sec. 34, T. 16 N., R. 21 W. of fifth principal meridian	828	....
B	In N. W. ¼ sec. 12, T. 16, R. 20 W	793	22,756
C	Near center of N. ½ of sec. 8, T. 16 N., R. 20 W	765	22,380
D	S. E. ¼ of same section as above	758	5,374
E	S. W. ¼ sec. 35, T. 16 N., R. 20 W	724	32,556
F	E. ½ sec. 33, T. 16 N., R. 19 W	698	35,956
	SEARCY COUNTY, ARK.		
G	Center of sec. 31, T. 16 N., R. 18 W	664	36,992
H	S. ½ sec. 11, T. 15 N., R. 18 W	631	41,052
I	Near center of sec. 5, T. 15 N., R. 17 W	595	29,720
J	South of center of sec. 31, T. 16 N., R. 16 W	556	50,316
K	Center of S. ½ sec. 22, T. 16 N., R. 16 W	540	23,150
L	E. ½ sec. 13, T. 16 N., R. 16 W	517	36,978
M	E. ½ sec. 4, T. 16 N., R. 15 W	490	42,089
	MARION COUNTY, ARK.		
N	Near center of sec. 26, T. 17 N., R. 15 W	471	35,488
O	N. E. ¼ sec. 23, T. 17 N., R. 15 W	452	44,156
P	N. E. ¼ sec. 23, T. 17 N., R. 14 W	421	36,844

No special effort was made to collect fishes, and the few taken in Rush Creek and in a small stream near Mount Hersey were damaged by the swamping of a boat and were not brought out. A number of game fishes, including rock bass, green sunfish, long-eared sunfish, and small-mouth black bass were caught by casting. A yellow cat (*Leptops olivaris*) was taken on a set line, and some residents had taken with a spear some other catfishes, which were identified as *Ameiurus aujuilla.* Suckers (the common white sucker and the red horse) were apparently common. Small fishes were nowhere abundant, the more common species being *Notropis zonatus.* No large-mouth black bass were seen until near Red Cloud mine, where one specimen was taken, and a second one jumped into our boat at the last station, but below Red Cloud mine fly fishing was very poor as compared with that in the river farther up.

MUSSEL BEDS LOCATED.

The exact location of the various mussel beds was rather difficult of determination. So few people were living along the stream that it was impossible to learn the local names of the fords, bluffs, and many of the shoals. It was possible, however, to locate the camps quite accurately and to approximate the distance between them, which enabled us to locate the beds fairly well, since they are usually found on the outer or bluff side of the river. Following is a list of the approximate localities where the collections of shells were made:

Station 1.—July 21, camp A. Immediately above the second ford above Welche's, where the Harrison-Jasper stage crosses the river, a few shells were found on gravelly bottom. Farmers living near

here state that several years ago shells were quite numerous and that one man could then perhaps have gathered 400 pounds in one day. This bed had been worked for pearls and so devastated by hogs that mussels are now very scarce. The river in places was not more than 30 feet wide, and, especially on and near shoals, the bed was gravel and sand; between these shallow places the river widens to from 50 to 100 feet, and flows with a sluggish current 4 to 6 feet deep over a rocky and muddy bottom.

A short distance below camp A is a small bed from which about 20 shells belonging to three species were taken during an hour's search. Many of these were dead, and only five were retained for the collection.

Shells taken at station 1: Rock mussel, washboard, *Quadrula undulata*, very abundant; *Unio gibbosus*, scarce; sand mussel, *Symphynota costata*, only one seen; *Strophitus edentulus.*

Station 2.—July 22, camp C. The character of the river was about the same as above. A few dead shells were observed, but no live ones were found.

Shells taken at station 2: White niggerhead, *Quadrula coccinea*, a few dead; rock mussel, washboard, *Quadrula undulata*, scarce; *Strophitus edentulus*, scarce; *Lampsilis planicostatus*, 1 specimen; butterfly, *L. ventricosus*, 1 live specimen, dead common.

Station 3.—July 23. From about 1 mile above to 1 mile below camp D.

Shells taken at station 3: Red niggerhead, *Quadrula tuberculata*, scarce; white niggerhead, *Quadrula coccinea*, scarce; *Unio gibbosus*, common; *Alasmidonta calceola*, 1 specimen; sand mussel, *Symphynota costata*, *Strophitus edentulus*, common; *Lampsilis venustus*, common; butterfly, *L. ventricosus*, abundant; *L. breviculus brittsi.*

After purchase of a wooden boat a trip was made down the Little Buffalo to the forks and back to camp. Inquiries were made along the river concerning shells in the Little Buffalo, all answers being to the effect that they were scarce and were always scarcer than in the Big Buffalo above the junction of these two streams. A local rain had swollen the stream and more water was flowing than in the Big Buffalo above the forks. It appeared to be the swifter of the two streams and its bed more rocky. From this camp to the mouth of the Little Buffalo the river flows mostly over gravel. A few dead shells were seen and fewer live ones were found. Just below the junction of the streams they were more numerous, but far from abundant. From about a mile below the forks to the next camp no beds were observed and but few shells or fragments of shell were seen on the shoals. Up to this time no shells were found which had been recently opened by pearl hunters.

Station 4.—July 26, camp E. Here there was a small mussel bed, where a few shells were taken.

Shells taken at station 4: White niggerhead, *Quadrula coccinea*, scarce; *Unio gibbosus*, abundant; niggertoe, *Alasmidonta truncata*, scarce; sand mussel, *Symphynota costata*, common; *Strophitus edentulus*, scarce; green mugget, red mugget, grass mucket, *Lampsilis ligamentinus*, *L. breviculus brittsi*, scarce.

Station 5.—July 26. About 2 miles below camp E a much larger bed was found. The pearl hunters had recently been here and about 100 freshly-opened shells were observed and a few live ones were found.

Shells found at station 5: Red niggerhead, *Quadrula tuberculata*, common; white niggerhead, *Q. coccinea*, scarce; cob shell, rabbit's foot, *Q. cylindrica*, 1 dead; sand mussel, *Symphynota costata*, abundant; green mugget, red mugget, grass mucket, *Lampsilis ligamentinus*, common; butterfly, *L. ventricosus*, scarce.

Station 6.—July 26. About 1 mile above camp F a small bed was observed, from which about 50 shells were taken during a search of and hour or more.

Shells found at station 6: Red niggerhead, *Quadrula tuberculata*, scarce; white niggerhead, *Q. coccinea*, common; *Unio gibbosus*, scarce; sand mussel, *Symphynota costata*, common; young fantail, *Cyprogenia aberti*, scarce; spectacle case, *Lampsilis rectus*, scarce; green mugget, red mugget, grass mucket, *L. ligamentinus*, scarce; butterfly, *L. ventricosus*, scarce; *L. breviculus brittsi*, scarce.

Station 7.—July 27. There were no beds of mussels observed for 3 or 4 miles below camp F, and very few dead or fragments of shells were found. About 1 mile above Mount Hersey a few shells were taken on a bed which extended through a longer course of the river. The shells, which were scarce, were found mostly among the larger rocks.

Shells found at station 7: Sand mussel, *Symphynota costata*, scarce; green mugget, red mugget, grass mucket, *Lampsilis ligamentinus*, scarce; *L. breviculus brittsi*, scarce.

None was found on an extensive sand and gravel bar at this point. The bed of the river is very rocky with quite extensive shoals both above and below Mount Hersey. A small bed was observed near the mouth of Cave Creek, its presence being made known by old shells and fragments on the gravel bars. No live mussels were seen, but a few were observed by one of the rodmen.

Station 8.—July 28. Above Wolem. A small mussel bed was observed about 1 mile below camp G. A much larger bed is located just above Wolem. Many mussels were seen here in the deeper water, and many had been recently opened by pearl hunters. This bed was at least three-quarters of a mile long, being much larger than any previously observed.

Shells found at station 8: White niggerhead, *Quadrula coccinea*, scarce; *Unio gibbosus*, scarce; sand mussel, *Symphynota costata*,

scarce; *Strophitus edentulus*, scarce; fantail, *Tritogonia tuberculata*, scarce; spectacle case, black sand-shell, *Lampsilis lienosus*, 7 taken; *L. venustus*, scarce; green mugget, red mugget, grass mucket, *L. ligamentinus*, most abundant species; butterfly, *L. ventricosus.*

The river widens just below this bed and runs over a gravel bar, much of the water evidently flowing through the gravel. It was so shallow that the boats, which drew about 5 inches of water, passed with difficulty.

Station 9.—July 29. About 2 miles from camp H lay a mussel bed about one-half mile long on a shoal. Many shells had been opened, but none recently. Live mussels were plentiful, many of them lying in sand between rocks. On this, as well as other beds observed, the shells were in such rocky places that tongs or other appliances could not be used, and all shells taken by pearl hunters were taken by hand. In an hour's collecting about 150 live shells were secured.

Shells found at station 9: Red niggerhead, *Quadrula tuberculata*, very abundant; white niggerhead, *Q. coccinea*, scarce; *Unio gibbosus*, common; niggertoe, *Alasmidonta truncata; A. calceola,* 1 found; sand shell, *Symphynota costata*, abundant; *Lampsilis ozarkensis*, abundant; *L. venustus*, scarce; green mugget, red mugget, grass mucket, *L. ligamentinus*, most abundant species; butterfly, *L. ventricosus*, scarce; *L. breviculus brittsi*, scarce.

Station 10.—July 29. About 5½ miles below camp H a small bed was found, and two other small beds were observed, one about 3½, the other about 5 miles from camp.

Shells found at station 10: Red niggerhead, *Quadrula tuberculata*, scarce; *Unio gibbosus*, scarce; sand mussel, *Symphynota costata*, scarce; fantail, *Tritogonia tuberculata*, scarce; spectacle case, *Lampsilis rectus*, scarce; green mugget, red mugget, grass mucket, *L. ligamentinus*, most abundant species.

Station 11.—July 30. About 2 miles below camp I there was a mussel bed less than one-half mile in length. Pearl hunters had opened many shells, but not recently.

Shells found at station 11: *Unio gibbosus,* scarce; sand mussel, *Symphynota costata*, scarce; spectacle case, *Lampsilis rectus; L. venustus*, scarce; green mugget, red mugget, grass mucket, *L. ligamentinus*, abundant; butterfly, *L. ventricosus; L. breviculus brittsi*, scarce.

Station 12.—July 30. About 3½ miles below camp I a small bed was found.

Shells taken at station 12: White niggerhead, *Quadrula coccinea*, scarce; *Unio gibbosus;* sand mussel, *Symphynota costata; Strophitus edentulus*, scarce; spectacle case, *Lampsilis rectus;* green mugget, red mugget, grass mugget, *L. ligamentinus*, abundant; *L. breviculus brittsi*, scarce.

Station 13.—July 30. About one-half mile below this last bed was a much larger one. A boy and a man were here hunting pearls, but they would give no information on the subject. There were on the shore at this place about 4 or 5 bushels of recently opened shells, by far the greatest number so far observed in one place.

Shells taken at station 13: Red niggerhead, *Quadrula tuberculata*, abundant; white niggerhead, *Q. coccinea*, scarce; *Unio gibbosus;* sand mussel, *Symphynota costata; Lampsilis ozarkensis*, scarce; red mugget, green mugget, grass mucket, *L. ligamentinus.*

Station 14.—August 1. A short distance above camp J, which was near the railroad station at Gilbert, was a small mussel bed; no specimens taken. About one-half mile below Gilbert is a fairly large bed lying on coarse gravel with larger fragments of rock and some sand. The depth of the water was about 2 feet. Three men, hunting pearls, were sitting on the bottom and digging the shells up with their hands. Each shell was opened at once, and if no pearl was found it was dropped and another one taken, every portion of the bed being examined. These men insisted they could take all they could find, and the next year as many more could as easily be found. The nature of the bottom was such that tongs or other devices could not be used profitably, for there were too many fragments of rock much larger than the shells and many about the size of the shells. Many of the shells were embedded beside the larger fragments and in some cases partly under them. Where the water was deeper the shells were collected in a bag and taken to the shore and opened. At this bed there was less than a bushel of shells on shore, while three or four times that amount were strewn over the bottom where the men were working.

Shells found at station 14: Red niggerhead, *Quadrula tuberculata*, abundant; cob shell, rabbit's foot, *Q. cylindrica*, common; *Unio gibbosus*, scarce; sand mussel, *Symphynota costata*, abundant; *Strophitus edentulus;* fantail, *Tritogonia tuberculata*, common; red shell, *Lampsilis purpuratus*, scarce; spectacle case, *L. rectus*, common; green mugget, red mugget, grass mucket, *L. ligamentinus*, abundant.

Station 15.—August 1. Below Gilbert, for about 2 miles, the current was quite rapid and the bottom very rocky. About 3½ miles below Gilbert was a considerable stretch of deeper water, bordered near the shallow water with sand and gravel bars. Mr. Cookson, a professional pearl hunter, had been working here for nearly a week. He had worked over the shallow places, and when we met him he was collecting in water about 5 feet deep. So many shells, he said, were between and under the edges of the larger rocks that tongs could not be used. His method was to have his sack for shells weighted down; by holding it with one hand he could draw himself under water and search for shells as long as he could hold his breath, after

which he would come to the surface, take a breath, and disappear again under water. During the week he had taken out of this bed about 10 bushels of shells, but did not believe many were left. From this bed a series was selected by Mr. Cookson and common names known to him were given them. Pearls, he says, are found mostly in the red and green muggets (muckets) and the washboards, and these shells are usually the most abundant. All shells taken, however, are opened for pearls. Mr. Cookson had hunted pearls for several years. He reported finding on an average pearls to the value of about $300 each year. The most valuable one found by him sold for $90.

Shells found at station 15: Red niggerhead, *Quadrula tuberculata*, common; white niggerhead, *Q. coccinea*, scarce; cob shell, rabbit's foot, *Q. cylindrica*, common; rock mussel, washboard, *Q. undulata*, common; *Unio gibbosus;* niggertoe, *Alasmidonta truncata;* sand mussel, *Symphynota costata;* young fantail, *Cyprogenia aberti;* fantail, *Tritogonia tuberculata;* red shell, *Lampsilis purpuratus; L. ozarkensis;* spectacle case, *L. rectus;* red mugget, green mugget, grass mucket, *L. ligamentinus; L. breviculus brittsi.*

Station 16.—August 2. About 3 miles below camp K (Cookson's camp) a collection was made from a bed about the size of the one mentioned above.

Shells found at station 16: White niggerhead, *Quadrula coccinea*, scarce; cob shell, rabbit's foot, *Q. cylindrica*, common; rock mussel, washboard, *Q. undulata*, more abundant than all other species; *Unio gibbosus*, scarce; sand mussel, *Symphynota costata*, common; fantail, *Tritogonia tuberculata*, scarce; young fantail, *Cyprogenia aberti*, scarce; red shell, *Lampsilis purpuratus*, scarce; *L. glans*, 1 specimen; *L. ozarkensis*, common; spectacle case, *L. rectus; L. venustus*, scarce; green mugget, red mugget, grass mucket, *L. ligamentinus*, abundant; butterfly, *L. ventricosus.*

Station 17.—August 2. About 5 or 6 miles below Cookson's camp a small bed was found and from it a collection was made. In the next mile two other very small beds were observed at the head of shoals in very rocky places. No collections were made from these beds.

Shells found at station 17: Red niggerhead, *Quadrula tuberculata*, abundant; white niggerhead, *Q. coccinea*, scarce; cob shell, rabbit's foot, *Q. cylindrica*, abundant; rock mussel, washboard, *Q. undulata*, abundant as all other species combined; *Unio gibbosus*, scarce; niggertoe, *Alasmidonta truncata*, sand mussel, *Symphynota costata*, scarce; *Strophitus edentulus*, common; fantail, *Tritogonia tuberculata*, scarce; *Lampsilis ozarkensis*, common; spectacle case, *L. rectus*, scarce; green mugget, red mugget, grass mucket, *L. ligamentinus*, abundant.

Station 18.—August 3. About 1 mile from camp L a mussel bed was being worked for pearls by two farmers, the shells being col-

lected in sacks and opened on the bank. About 5 bushels of shells had been taken.

Shells found at station 18: Red niggerhead, *Quadrula tuberculata*, abundant; white niggerhead, *Q. coccinea*, scarce; cob shell, rabbit's foot, *Q. cylindrica*, common; rock mussel, washboard, *Q. undulata*, very abundant; *Unio gibbosus*, scarce; sand mussel, *Symphynota costata*, abundant; fantail, *Tritogonia tuberculata*, scarce; red shell, *Lampsilis purpuratus*, scarce; spectacle case, *L. rectus*, scarce; green mugget, red mugget, grass mucket, *L. ligamentinus*, abundant.

Station 19.—August 3. Below station 18 for a mile or two were a few small beds which had recently been worked by pearl hunters. In all of these there was probably not more than a bushel of open shells.

Shells found at station 19: Red niggerhead, *Quadrula tuberculata*, very abundant; cob shell, rabbit's foot, *Q. cylindrica*, common; rock mussel, washboard, *Q. undulata*, abundant; *Unio gibbosus*, scarce; sand mussel, *Symphynota costata*, scarce; young fantail, *Cyprogenia aberti*, scarce; fantail, *Tritogonia tuberculata*, scarce; *Lampsilis ozarkensis;* green mugget, red mugget, grass mucket, *L. ligamentinus.*

Station 20.—August 3. About 6 miles below camp L and near the Jack Pot mine a small bed of shells was observed. About 1 bushel had been recently opened by pearl hunters. From these and a few live ones found a collection was made.

Shells found at station 20: Red niggerhead, *Quadrula tuberculata*, scarce; rock mussel, washboard, *Q. undulata*, common; fantail, *Tritogonia tuberculata*, scarce; red shell, *Lampsilis purpuratus*, scarce; *L. ozarkensis*, scarce; spectacle case, *L. rectus*, scarce; green mugget, red mugget, grass mucket, *L. ligamentinus*, common.

Station 21.—August 4. About 1 mile below camp M were two beds of mussels. These had within a day or two been worked by pearl hunters, the shells being opened on the bank. Not more than 2 or 3 bushels had been taken from both of these beds, which were on the outer curve of the river and among more rocks than usual.

Shells found at station 21: Red niggerhead, *Quadrula tuberculata*, abundant; white niggerhead, *Q. coccinea*, scarce; cob shell, rabbit's foot, *Q. cylindrica*, common; rock mussel, washboard, *Q. undulata*, abundant; *Unio gibbosus*, scarce; sand mussel, *Symphynota costata*, scarce; *Strophitus edentulus;* fantail, *Tritogonia tuberculata*, scarce; spectacle case, *Lampsilis rectus*, scarce; green mugget, red mugget, grass mucket, *L. ligamentinus*, common; butterfly, *L. ventricosus*, scarce.

Station 22.—August 4. About 5 miles below camp M a bed similar to the above was found and from it a collection was made.

Shells found at station 22: Red niggerhead, *Quadrula tuberculata*, common; cob shell, rabbit's foot, *Q. cylindrica; Unio gibbosus*, scarce; sand mussel, *Symphynota costata*, scarce; fantail, *Tritogonia tuber-*

culata, scarce; red shell, *Lampsilis purpuratus*, common; green mugget, red mugget, grass mucket, *L. ligamentinus*, abundant.

Along the river on its outer bends a few very small beds were observed. Owing to the small number of shells, deeper water, and the large rocks, these beds were not worked by pearlers.

Station 23.—August 5. About 2 miles below camp N was found the largest bed observed. It was being worked by two men and two women who live near by and hunt pearls a portion of the time in July and August when their crops do not need their attention. They reported that pearls collected by them during the summer months brought them about $300. Mr. Samuel W. Jones, Rush, Ark., one of the men, stated that if all the shells found in one season were taken from the bed just as many would be found the next year. From this bed they estimated they would take about 25 bushels of shells. They had just begun work for the season. The most abundant species found here is *Lampsilis ligamentinus*, which, according to Mr. Jones, contains the most pearls. At this place this species was more abundant than all others combined.

Shells found at station 23: Rock mussel, washboard, *Quadrula undulata*, scarce; *Unio gibbosus*, scarce; fantail, *Tritogonia tuberculata*, common; green mugget, red mugget, grass mucket, *Lampsilis ligamentinus*, abundant.

Station 24.—August 5. About 1 mile above the Red Cloud mine we passed a bed of shells where pearl hunters had been, but it was very small compared to the above.

On all outward bends of the river were small beds, but these were passed by by pearl hunters, no doubt because shells were scarce, and on account of the rocks and deeper water they were difficult to get in any numbers. A short distance above and below the mouth of Rush Creek were small beds, the latter being worked by pearl hunters. No collection was made from these beds.

Shells found at station 24: Red niggerhead, *Quadrula tuberculata*, scarce; cobshell, rabbit's foot, *Q. cylindrica*, common; rock mussel, washboard, *Q. undulata*, common; *Unio gibbosus*, common; sand mussel, *Symphynota costata*, scarce; fantail, *Tritogonia tuberculata*, scarce; red shell, *Lampsilis purpuratus; L. ozarkensis*, abundant; *L. planicostatus*, 1 specimen; spectacle case, *L. rectus*, scarce; *L. venustus*, scarce; green mugget, red mugget, grass mucket, *L. ligamentinus*, abundant; butterfly, *L. ventricosus*, scarce; *L. breviculus brittsi*, scarce.

Station 25.—August 6. About 2½ miles below Red Cloud mine a large bed was found which had been recently visited by pearl hunters. On the shore were about 10 bushels of recently opened shells, from which a collection was made. On recently worked beds live shells were not easily found, for the pearlers aim to get everything.

Shells found at station 25: Red niggerhead, *Quadrula tuberculata*, common; white niggerhead, *Q. coccinea*, common; cob shell, rabbit's foot, *Q. cylindrica*, common; rock mussel, washboard, *Q. undulata*, abundant; *Unio gibbosus*, scarce; sand mussel, *Symphynota costata*, common; *Strophitus edentulus*, scarce; young fantail, *Cyprogenia aberti*, scarce; fantail, *Tritogonia tuberculata*, common; red shell, *Lampsilis purpuratus; L. ozarkensis*, scarce; spectacle case, *L. rectus*, common; green mugget, red mugget, grass mucket, *L. ligamentinus*, most abundant species; *L. luteolus*, two examples taken; butterfly, *L. ventricosus.*

Station 26.—August 6. In the next 2 or 3 miles a few small beds were found and then a second large one, where about 5 bushels of recently opened shells were seen.

Shells found at station 26: Red niggerhead, *Quadrula tuberculata.* common; cob shell, rabbit's foot, *Q. cylindrica*, scarce; sand mussel, *Symphynota costata*, scarce; spectacle case, *Lampsilus rectus*, scarce; green mugget, red mugget, grass mucket, *L. ligamentinus.*

From this place to our next camp (camp P) very few shells were noticed.

Soon after camp P was established a succession of heavy thunder storms raised the river about 5 feet and the usually clear water became muddy. Under the most favorable circumstances it would be a week or more before any further observations regarding shells could be made, and so the work was discontinued here. Residents near here state that mussel beds occur from this point to the mouth of the river much the same as to number and abundance of shells as in a corresponding distance up stream from this place.

List of Mussel Species Collected.

Local name.[1]	Common or trade name.	Scientific name.
Red niggerhead	Pink warty-back	Quadrula tuberculata.
White niggerhead		coccinea.
Cob shell, rabbit's foot		cylindrica.
Rock mussel, washboard	Blue-point	undulata.
——	Spike	Unio gibbosus.
Niggertoe	Elk-toe	Alasmidonta truncata.
——		calceola.
Sand mussel	Fluted shell	Symphynota costata.
——	Squaw-foot	Strophitus edentulus.
Young fantail		Cyprogenia aberti.
Fantail	Buckhorn	Tritogonia tuberculata.
Red shell		Lampsilis purpuratus.
——		glans.
——		ozarkensis.
——		planicostatus.
Spectacle case		lienosus.
Spectacle case	Black sand shell	rectus.
——		venustus.
Green mugget, red mugget, grass mucket		ligamentinus.
——	Fat mucket	luteolus.
Butterfly	Pocketbook	ventricosus.
——		breviculus brittsi.

[1] The local names given here are those furnished by pearlers along the river and differ considerably from the trade names among the shell buyers and manufacturers, so far is the Little Buffalo River from the influence of the active shell trade. In the button trade *Quadrula tuberculata, Q. coccinea, Alasmidonta caceolla, Strophitus edentulus, Cyprogenia aberti, Lampsilis purpuratus, glans, ozarkensis planicostatus, lienosus, venustus,* and *breviculus brittsi* have no common names. *Q. undulata* is "blue-point," *Unio gibbosus* is "spike," *S. costata* is "fluted shell," *Tritogonia tuberculata* is "buckhorn," *L. ligamentinus* is simply "mucket," *L. luteolus*, "fat mucket," and *L. ventricosus* "pocketbook." On the other hand, the washboard of the trade is *Quadrula heros* and the butterfly is *Plagiola securis.*

DISTRIBUTION OF MUSSEL SPECIES.

Red niggerhead, Quadrula tuberculata (*Rafinesque*).—Rather common throughout the whole extent of the river traversed. The species is represented by 78 examples of various sizes, none very large and none very small. The shells do not exhibit much variation; they belong to a small, somewhat inflated type, much like those found in the streams of Kentucky and Tennessee. The specimens taken at station 6 were rather inflated compared with the others, and those obtained at station 26 were relatively small and thin. None were sufficiently inflated, however, to be regarded as *Q. granifera*, which differs from this species chiefly in degree of inflation, and none was so flat as the fine specimens of *Q. tuberculata* found in the Maumee, Tippecanoe, and Wabash Rivers, where the species appears to reach its finest development. All lacked the fine wavy sculpture of the umbones which is characteristic of the young of *Q. tuberculata* in its most perfect condition. The name "red niggerhead" was applied to this shell at the pearler's camp below Gilbert. On account of its colored and lusterless nacre this shell has little commercial value.

It was found at the following stations: 3, scarce; 5, common; 6, scarce; 9, very abundant; 10, scarce; 13, abundant; 14, abundant; 15, common; 17, abundant; 18, abundant; 19, very abundant; 20, scarce; 21, abundant; 22, common; 24, scarce; 25, common; 26, common.

White niggerhead, Quadrula coccinea (*Conrad*).—Although fairly well distributed, having been collected through nearly all the stretch of river traversed, and at 14 different stations, *Quadrula coccinea* does not appear to be common in the river. In all, 42 shells were obtained. The greatest number taken at one place was 9, collected at station 6. The shells are all rather small and moderately inflated. The greater number have white nacre, though a few are pink. At the pearler's camp it was called "white niggerhead." This species probably really belongs to *Pleurobema*, as Ortmann has found the outer gills only functioning as marsupia. It is, however, quite variable and may include several species. I have never found the common flat form gravid. An inflated form, identified as this, but approaching somewhat the shape of *Q. solida*, was found gravid in the Iroquois River and contained glochidia in only the outer gills. Where the species attains a good development the white-nacre shells furnish very fair button material, but the rather dwarf shells of the Big Buffalo River are of no commercial value.

It was found at the following stations: 2, a few dead shells; 3, scarce; 4, scarce; 5, scarce; 6, common; 8, scarce; 9, scarce; 12, scarce; 13, scarce; 15, scarce; 16, scarce; 17, scarce; 18, scarce; 21, scarce; 25, common.

Cob shell, rabbit's foot, Quadrula cylindrica (*Say*).—The first one, a dead shell, was taken at station 5. From here on it was, on the whole, rather common. The greatest number taken at any one place was 13, at station 25. In all, 59 examples were secured. At the pearler's camp it was called "cob shell." Along the Wabash it is known as "rabbit's foot." The nacre of all found is white, though many are more or less stained. Several were beautifully marked by green triangular marks and some were semitranslucent. None was young and most were of medium size. The species has no commercial value.

It was found at the following stations: 5, one dead; 14, common; 15, common; 16, common; 17, abundant; 18, common; 19, common; 21, common; 24, common; 25, common; 26, scarce.

Rock mussel, washboard, Quadrula undulata (*Barnes*).—Common to abundant throughout the part of the river examined and represented in the collection by 61 shells. The shells are of the same general type, medium in size and rather inflated. None is so compressed as the fine examples to be found in northern Indiana and Ohio and none so markedly inflated as to suggest *plicata.* Within the limits suggested there is some variation in the degree of inflation. Those obtained at station 16 are somewhat flat, and one is almost smooth. One obtained at the Jack Pot mine is markedly elongate as compared with the others, but not conspicuously so when compared with large series from elsewhere. The shells collected at station 26 are considerably eroded. The greater number of these shells exhibit well-marked costæ on the posterio-dorsal slope, with deep furrows between them. High ribs extending ventrad from the posterior slope and separated by deep furrows are also common. In these features the shells resemble a common type of the west and south and approach the style represented by Say's figure of *Unio costatus.* At the pearler's camp they were called "rock mussel," or "washboard."

Where this species attains good development it is a good commercial species, but the Big Buffalo shells are small and of poor quality.

It was found at the following stations: 1, most abundant; 2, scarce; 16, abundant; 17, abundant; 18, most abundant; 19, abundant; 20, common; 21, abundant; 23, scarce; 24, common; 25, abundant; 26, abundant.

Unio gibbosus (*Barnes*).—Common; represented in the collection by 77 specimens. As a usual thing only a few shells were obtained at a station. The greatest number obtained at one place was 10, collected at station 24. The most common form is the familiar medium-sized shell with violet nacre. Those obtained at station 3 and those collected at station 12 are large shells with white porcelaneous nacre. The five examples taken at station 6 are dwarfed specimens with

orange nacre, closely resembling a form common in Green River, Ky. This species is of no commercial importance.

It was found at the following stations: 1, scarce; 3, common; 4, abundant; 6, scarce; 8, scarce; 9, common; 10, scarce; 11, scarce; 14, scarce; 16, scarce; 17, scarce; 18, scarce; 19, scarce; 21, scarce; 22, scarce; 23, scarce; 24, common; 25, scarce.

Niggertoe, Alasmidonta truncata (B. H. Wright).—Rare; only seven shells obtained, one at station 4, one at station 9, another at station 12, and three at station 15, where it was called "niggertoe." Where it reaches its best development this is a beautiful shell. It is however, of no commercial importance.

Alasmidonta calceola (Lea).—Only two shells were collected, one at station 3 and one at station 9. This does not necessarily mean that it is rare, as on account of its small size and habit of burying itself in the bottom it is easily overlooked.

Sand mussel, Symphynota costata (Rafinesque).—A fairly common shell, found throughout the entire length of the river examined, and represented in the collection by 90 specimens. Most of the shells are of medium size, a few are smaller, but none very small, the smallest being about 3 inches long. There is no very marked variation among them; one specimen obtained at station 6 is compressed and somewhat deformed, and one from station 19, probably a female, is inflated, with deep costæ. At station 15 they were called "sand mussels." On account of the yellowish, lusterless nacre and usual thinness of shell, mussels of this species have no commercial value.

It was found at the following stations: 4, common; 5, abundant; 6, common; 7, scarce; 8, scarce; 9, abundant; 10, scarce; 11, scarce; 14, abundant; 16, common; 17, scarce; 18, abundant; 19, scarce; 21, scarce; 22, scarce; 24, scarce; 25, common; 26, scarce.

Strophitus edentulus (Say).—Although this shell is found throughout all the portion of the river examined, it is rather scarce nearly everywhere and nowhere abundant. One shell found at station 2 was short and truncate. The others were much alike and quite thin. *Strophitus edentulus* is an exceedingly variable shell, especially as regards thickness, and the nacre varies from bluish to yellowish. Even the best shells are of no commercial value.

It was found at the following stations: 2, scarce; 3, common; 4, scarce; 12, scarce; 17, common; 25, scarce.

Young fantail, Cyprogenia aberti (Conrad).—Not common; only 10 examples secured, the first one at station 6, and the last three at station 25. Most of the specimens are rather old and somewhat worn, a few are of medium size with the epidermis entire. Call suggests a resemblance between a young *C. aberti* and *Plagiola elegans*. The half-grown shells of this collection have rather the contour of *Quadrula lachrymosa*, but are without tubercles, only very low elongated

raised places, hardly pronounced enough to be called pustules, extending ventrad. The species is not nearly so pustulose as *C. irrorata* (Lea). The fine tesselated markings, green on a yellowish ground, sometimes disposed in broad rays, are similar to the color markings of the last-named species, and assist in identifying the species.

It was found at the following stations: 6, scarce; 16, scarce; 19, scarce; 25, scarce.

Fantail, Tritogonia tuberculata (*Barnes*).—From the place where first encountered, station 8, to station 25 this is a fairly common shell, though rather scarce at some stations. In all, 48 shells were taken. At station 15 it was known as "fantail." The shells are all relatively small and thin, and most of them exhibit the peculiarity of having a purplish nacre, only very few being white, but none so deep a purple as frequently occurs in specimens from Texas. In the Iowa and upper Mississippi Rivers, where this species attains large size and always or most always has a white iridescent nacre, it is valuable for buttons, knife handles, etc., but the thin purplish Arkansas shells are of no commercial value.

It is significant that though the greater number of these shells have colored nacre, *Lampsilis ligamentinus*, which is frequently rose tinted in the upper Mississippi, and *Quadrula coccinea*, which often has rose-tinted nacre everywhere, show little disposition here to develop colored nacre, this in the greater number of cases being white. This shows clearly that the causes producing tinted nacre are not the same for all species, and may be an individual peculiarity.

It was found at the following stations: 8, scarce; 10, scarce; 14, common; 16, scarce; 17, scarce; 18, scarce; 19, scarce; 20, scarce; 21, scarce; 22, scarce; 23, common; 24, scarce; 25, common.

Red shell, Lampsilis purpuratus (*Lamarck*).—Fairly common from station 14 to station 25, 25 shells having been secured in this portion of the river. They exhibit no variation except in size. Some of the examples are rather small, but the greater number are of good size. The young shells are thin and fragile, but later become thick and heavy. The species closely resembles *L. alatus* in the color of nacre, which is rich purple, and that of the epidermis, which is black. It differs from that species in being considerably more inflated and with very little wing. The species is rather closely related to *L. alatus* and is said to have a wedge-shaped glochidium, which would agree with that of *alatus*. At station 15 it is known as the "red shell."

It was found at the following stations: 14, scarce; 16, scarce; 18, scarce; 20, scarce; 22, common.

Lampsilis glans (*Lea*).—Only one specimen of this small species was found. It was obtained at station 16. It is inconspicuous both in color and size and is liable to be overlooked even where fairly common.

Lampsilis ozarkensis (*Call*) *var.*—These specimens, unlike anything we could find a figure or description of, more closely resemble a very elongated *Quadrula coccinea* than anything else, agreeing with that species both in texture of epidermis and color of nacre, which is usually a rich rosy, though occasionally white. Examples were submitted to Mr. Bryant Walker, of Detroit, Mich., who has made a special study of fresh-water mussels and identified them as above. Mr. Walker remarks:

> Not typical. I have author's examples. But these agree with a shell I have, so named, from Hardy. Taken by themselves, I should say that these shells were *Pleurobemas* rather than a species of *Lampsilis*. They are not, however, Simpson's *elliptica*. Alcoholic specimens, which would enable the generic place to be established, would be desirable.

These shells also agree fairly well with specimens labeled *ozarkensis* in the Davenport Academy of Sciences, with which they have been compared.

This form was fairly common between stations 9 and 25, 20 examples having been secured.

It was found at the following stations: 9, abundant; 13, scarce; 16, common; 17, common; 20, scarce; 24, abundant; 25, scarce.

Lampsilis planicostatus (*Lea*).—Only two examples, both females, one from station 2 and one from station 24. These were submitted to Mr. Bryant Walker, who remarks, "A very interesting find. The first record west of the Mississippi, I believe. Male examples would be very desirable." The shells are elongate, somewhat resembling a long flattened *iris*, but without the brilliant radiation of that species.

Spectacle case, *Lampsilis lienosus* (*Conrad*).—Seven examples of this small species were found, all at station 8, and above Wolem. All had the nacre deep purple, and one of the small females bore a considerable resemblance to a large *Lampsilis glans*. A specimen was submitted to Mr. Bryant Walker, who identified it as above. It is a fairly common shell in southern streams.

Spectacle case, *black sand shell*, *Lampsilis rectus* (*Lamarck*).—Rather scarce. The first shells of this species were taken at station 6. In all, 46 shells were secured. One dead shell had a colony of *Plumatella polymorpha* growing on the inside of one valve. Most of the shells of this species were of medium size and rather poor quality. White-nacred shells are the rule rather than the exception, which is the reverse of the situation in parts of the upper Mississippi, where most of the shells are purplish. Where this shell attains large size and has white nacre it is an excellent commercial species. At the pearler's camp, station 15, it was called "spectacle case." In the button trade it is known as the "black sand shell," while the former name is applied to *Margaritana monodonta*.

It was found at the following stations: 6, scarce; 10, scarce; 14, common; 17, scarce; 18, scarce; 20, scarce; 21, scarce; 24, scarce; 25, common; 26, scarce.

Lampsilis venustus (*Lea*).—Not common, but well distributed, the first 11 being taken at station 3 and the last one at station 24. In all, 19 specimens were secured. Mr. Bryant Walker, to whom the specimens were referred and who identified them, in remarks concerning some of the specimens says, " On the whole they seem to be between *venusta* and *pleasii.* More material from different localities would be very desirable."

This is a small species attaining the length of about 50 millimeters. Most of the females have a peculiar sulcus extending from the post ventral margin dorsad, and the epidermis with exceedingly fine capillary rays posteriorly. Mr. Walker calls attention to their close relationship and similarity to *L. ellipsiformis* (Conrad). Call is of the opinion that *venustus* and *pleasii* are the same.

It was found at the following stations: 3, common; 8, scarce; 9, scarce; 11, scarce; 16, scarce; 24, scarce.

Green mugget, *red mugget*, *grass mucket*, *Lampsilis ligamentinus* (*Lamarck*).—This is much the most abundant species found in the river, and is represented by 216 shells obtained at numerous stations from station 5 down to station 26. There are four without data. Only a few of the shells have rosy nacre. There is great variation in size, form, and general appearance. Most of the various forms found in widely different localities are found in this one river, not in widely separated parts of the river, however, but in the same mussel bed. Two examples from station 5 are very thick and heavy. One other from the same place is flattish, with broad rays, and another one is small, flattened, and rayless. This latter depauperate form, resembling a style common in Green River, Ky., is a common type in the river. One specimen, collected at station 9, and one from station 23, are remarkably inflated and elongate. One shell collected at station 19 is inflated and arcuate, having the general shape of *Symphynota costata.* At station 15 a specimen with broad green bands and a greenish epidermis, the kind known by clammers along the Mississippi as the " grass mucket " was called " green mugget " and one with a rusty epidermis and no rays was called " red mugget."

Although the mucket, *Lampsilis ligamentinus*, is one of the staple shells used in button manufacture, those of the Big Buffalo River are of little commercial value on account of their general small size and lack of uniformity.

It was found at the following stations: 5, common; 6, scarce; 7, scarce; 8, very abundant; 9, very abundant; 10, very abundant; 11,

abundant; 12, abundant; 14, abundant; 16, abundant; 17, abundant; 18, abundant; 20, common; 21, common; 22, abundant; 23, abundant; 24, abundant; 25, abundant.

Lampsilis luteolus (*Lamarck*).—Rare; only two examples obtained, both at station 25. They were rather small for river shells, but heavier than the form usually found in lakes.

Butterfly, *Lampsilis ventricosus* (*Barnes*).—Not very abundant, but found distributed throughout most of the length of the stream examined. In all, 22 specimens were found. Most of the shells were well rayed. They exhibited the usual variation in form. One shell collected at station 6 is a short inflated female, bearing a general resemblance to *L. capax*, but thick. One shell, obtained at station 8, was small, well rayed, and more closely approaching the shape of *L. ovatus*, and had a yellowish epidermis well rayed with green.

It is only at its best that *L. ventricosus* is a good button shell, and those of Big Buffalo River are only moderately good shells.

It was found at the following stations: 2, one live shell; 3, abundant; 5, scarce; 6, scarce; 9, scarce; 21, scarce; 24, scarce.

Lampsilis breviculus brittsi (*Simpson*).—This shell is new to the collection of the bureau, and was identified by Mr. Bryant Walker. It agrees fairly well with examples of *breviculus* Call, in the Davenport Academy of Sciences, with which specimens were compared, but is broader and flatter posteriorly. It is a flattened shell bearing some resemblance to a small, thin, considerably produced *Lampsilis luteolus*, but not markedly inflated postero-ventrally. The numerous green rays are much interrupted and broken up by the lines of growth. Two examples from station 4 have rather rosy nacre. There are 28 shells in the collection. The first five were obtained at station 3 and the last one at station 24.

It was found at the following stations: 4, scarce; 6, scarce; 7, scarce; 9, scarce; 11, scarce; 12, scarce; 24, scarce.

PRELIMINARY EXAMINATION OF HALIBUT FISHING GROUNDS OF THE PACIFIC COAST

By A. B. Alexander

WITH

INTRODUCTORY NOTES ON THE HALIBUT FISHERY

By H. B. Joyce

Bureau of Fisheries Document No. 763

INDEX TO LOCALITIES EXAMINED.

INTRODUCTORY NOTES ON THE HALIBUT FISHERY.

By H. B. Joyce.

Halibut, which have been sold in the markets of the United States as food fish for many years, were, prior to 1850, very abundant off the coast of New England and the maritime Provinces. They were however, shunned by fishermen seeking cod and other species, and when caught were frequently cut from the hooks. The combative nature of the halibut tends to drive cod and other desirable fish from the hooks of a trawl or hand line, and sometimes from the ground.

When properly prepared and packed in ice immediately after being caught, kept from the light and air, with a temperature as near the freezing point as possible without actually freezing the fish, halibut will remain in good condition from three to four weeks, and at the end of the time will be perfectly sweet and fresh. Because it is possible to keep halibut in good condition longer than most kinds of fish they are greatly in demand by dealers; and they possess, moreover, a greater commercial value than other bottom species, largely on account of the attractive whiteness of their flesh. They are also an easily digested food.

The demand for halibut is quite as great as for salmon, mackerel, and other oily species. Even after being kept until the freshness has departed, they can be prepared and eaten without danger.

When the demand for halibut reached a stage calling for all that could be procured, both fresh and salted, the rapidly growing industry soon depleted the banks of the Atlantic coast, until it was possible at times for fishermen to receive as high as 30 cents a pound for small trips. The uncertainty of the supply and the consequent fluctuation in price led to the inauguration of the halibut industry on the Pacific coast, in the waters of Washington, British Columbia, and southeast Alaska.

The first attempts on the west coast were crude and unsatisfactory. The fleet of small craft gradually developed, however, into a better class of vessels. Sail vessels gave way to small steamers, some of which were chartered. The steamers at first purchased a considerable portion of their cargo from the Indians. Unfortunately many

of the fish obtained in this manner were never paid for, and in some instances the crews of the vessels received no compensation for their labor.

The fish were usually taken to the first market available, generally Seattle or Tacoma, from which points they were shipped to New York and Boston.

Previous to 1894 little or no profit was realized from the fishery, and from the fishermen's point of view the case seemed to be hopeless; but the introduction of Pacific coast halibut in the markets of the East aroused the fish dealers of New England to a realization of the importance of the new source of supply. A combination was formed sufficiently large to prosecute the fishery in the same manner as conducted on the Atlantic coast and powerful enough to secure from the railroads low rates of transportation across the continent, and also means of prompt delivery to local points. This also applied to all other kinds of fish shipped. When these fish reached the East in carload shipments they were delivered to local dealers in small quantities for daily trade. At first strong objection was made to the Pacific coast halibut on the ground of quality, but for this there was little foundation, the Pacific fish being quite as valuable as those of the Atlantic coast.

In shipping fish the main requirement is their proper state of preservation on arriving at their destination, a feature of the business that frequently has been overlooked. An expert in the fisheries of the Atlantic coast was engaged to superintend the catching and handling of halibut, and unremitting care to the improvement of every detail connected with the fishery resulted in landing the fish at the shipping point in an inviting condition, to the satisfaction of both dealer and consumer.

As early as 1888 and 1889 attempts were made to fletch halibut, but they were soon abandoned on account of the small demand for the smoked product. Fletching, however, is likely to lead to wanton destruction of fish, as fully one-half of the halibut caught are too small for the purpose, and in consequence are often thrown away. Such was the case with the few trips of fletched halibut taken on Cape Scott and Queen Charlotte Islands grounds.

No authentic information is to be had regarding the age of halibut. It is thought, however, that more than 20 years are required for the fish to reach full growth. While the halibut caught seldom weigh more than 200 pounds, individuals have been taken weighing 400 pounds. The largest specimens have been taken off the coast of Newfoundland. The average weight of the Pacific coast halibut will not exceed 30 pounds. It is probable that fish of this size are about 5 years old. Larger fish are found from Cape Scott northward than on grounds farther south.

In the early history of the Pacific halibut fishery a large portion of the catch was taken in waters on the south side of Dixon Entrance, in Hecate Strait, between Queen Charlotte Islands and the islands fringing the coast of British Columbia on the east side of the strait. The Indians of this region had fished in these waters from time immemorial, obtaining an ample supply of fish for their needs, and they furnished the first information to the white man of the abundance of halibut on grounds adjacent to their villages. They were instinctively very reluctant to impart the information desired, and with good reason, but constant persuasion on the part of white fishermen and a promise of 50 cents a fish to the Indians for all the latter might catch were inducements too great for the Indians to resist. Fish were furnished by these people which were never paid for; and in a very short time the white fishermen had acquired full knowledge of all the local grounds pointed out by the Indians and all others which they could locate.

At this period eastern fishermen began to appear on the ground, backed by a considerable amount of capital, and having devised means of distributing large quantities of fish, were in a position to equip and operate a fleet of sufficient size to supply the market in carload lots. A steamer which in the previous winter had been engaged in the same fishery and had met with loss was chartered by the new company, and several members of her crew were induced to continue in the fishery. Instead of dories Columbia River boats were used in setting the trawls. Lumber for camps, a scow for a dock, and necessary supplies were shipped from Puget Sound ports, and a fishing station erected on shore near the best-known fishing ground. The place selected was near the west end of Banks Island in Hecate Strait. The boats were manned by two men each and furnished with the necessary amount of gear, 1,200 fathoms of trawl. They were paid 25 cents a fish, one-half the sum promised to the Indians. This was afterwards changed to 1 cent per pound.

This industry started by eastern dealers caused competition to arise in British Columbia. Two firms were inaugurated, working on the plan adopted by the New England dealers, and the vessels belonging to these firms met on a small fishing ground near the west end of Banks Island, where there was only room for one vessel to set gear. In one month's time they had so depleted the ground that its yield was reduced to a minimum, and an extensive search for halibut failed to offer any hope for a profitable catch for some time in the future. The enforced idleness of the crew, combined with the necessity of doing something toward paying for the outfit and running expenses of the vessels, caused a more thorough search to be made on the sloping side of an extensive bank composed of bowlders and sand which lies from 5 to 10 miles off the rocky shore fringing the coast.

The ground when first discovered furnished a large supply of halibut, and fish were very plentiful on all parts of it. As soon as a scarcity of fish was noticed in any one place, the vessels shifted to another part, and under these conditions the ground yielded continuously for three winters. At the end of this time a large area had been covered, extending from a point 5 miles southeast from the west end of Banks Island along the sloping edge of the ground to Rose Spit, a sandy point situated on the northern end of Graham Island of the Queen Charlotte group, covering a ground about 50 miles long by 4 miles wide.

During this time the fishermen had become more expert, and at the end of the third season they were able to handle double the amount of gear they did at the beginning of the fishery. The method of caring for the catch had also been improved upon. The fish were dressed, iced, and stowed away in the hold in less than half the time formerly required. Full fares were quickly obtained, and in many instances placed on the market in better condition than trips landed by halibut vessels of the Atlantic coast.

Large profits were made and the business increased until the railroad rates became an important factor in railroad business. The increased efforts on the part of fishermen to produce fish and the opening of extensive markets in the Middle West caused more vessels to engage in the fishery, and in 15 years from the time of its inception there was a noticeable decline in the supply. The original fishing grounds in Hecate Strait and Dixon Entrance gave small returns as compared to the catch of previous years.

In the meantime, however, new banks had been discovered. Occasionally a vessel would repair to the original ground in the hope that the depletion caused by the overfishing was only temporary, similar conditions having prevailed on the halibut banks of the Atlantic, and the contention among fishermen being that halibut were as plentiful as ever, only that they had migrated to undiscovered grounds. Little was known of the halibut banks along the stretch of coast west of Dixon Entrance to Bering Sea, or, for that matter, of the ground from 20 to 40 miles offshore between Cross Sound and Yakutat Bay.

The sharp competition in the fishery has led to increased effort to secure large catches in the quickest possible time, and this necessarily involves the use of more extensive fishing gear. Where formerly 4 skates of trawl, of 6 lines each, was considered a sufficient outfit for two men, the same number of men now operate from 8 to 10 skates (bundles) of 8 lines each, equal to 3,500 fathoms, or 21,000 feet. This line is set in one continuous string, covering a distance of approximately 4 miles.

The Columbia River boats originally used in the Pacific halibut fishery have given place to the dories used in the Atlantic industry. The dories now employed, however, are 20 feet long, an increase of 2 feet over the length of those formerly used, because of the additional gear handled. The Pacific fishermen operate from two to four more skates of trawl to a dory than are generally "run" by fishermen on the Atlantic coast, this in a measure because of the comparative shallow water in which halibut have been taken, and the close proximity of these banks to the mainland, where much greater risk can be taken than on grounds situated far from the coast.

To lessen the labors of unloading by handling the fish separately, dories are now fitted with a heavy net, covering the bottom and sides to the risings, which when brought together at the top forms a bag. The fish when taken from the hooks are thrown into the bottom of the dory, between the parting boards, in the usual manner. When a dory has secured a load the net is drawn together at the top by the rope to which it is hung. A signal is then made to the vessel indicating a desire to unload. The steamer runs alongside, a tackle is lowered, and the contents of the bag hoisted on deck. The time occupied in performing this operation seldom exceeds three or four minutes. The dory is furnished with another net and left to finish hauling the trawl; the steamer in the meantime goes to other dories requiring assistance.

This method of transferring halibut from the dories to the steamer has proved very satisfactory, and saves a great deal of time and labor, making it possible to catch and handle nearly twice as many fish in a day as by the old system. The net was invented by Capt. H. B. Joyce and used by him several years before it became generally adopted.

A steamer usually carries 12 to 14 dories, equipped with the quantity of fishing gear mentioned. On good fishing ground the trawls are set parallel to each other, about one-third of a mile apart, the area covered by the trawls of a single vessel sometimes exceeding 15 square miles, or 9,000 acres. One fish to 2 acres of ground is a catch seldom taken. An area fished upon one day seldom yields more than one-half as much the day following. The increased number of steamers makes it almost necessary for one or more to fish on the same ground several days in succession.

Another result of the competition, and one which imperils the lives of fishermen, is the reckless regard they have for weather conditions. Where formerly fishing was carried on in weather which boats could ride out in safety, it is now a common practice to fish when the sea is running high. As the trawl is hauled the danger grows if fish are being caught, and when a dory is loaded or partially loaded the occupants are in a precarious position. Care and skillful management must be exercised in coming alongside of the steamer and discharging

the fish, and cases are known where the men have been flung bodily from the dory by a sea, the dory turned bottom up, and the men forced to cling to the bottom of the boat until rescued by the steamer or another boat. In the last 18 years about 12 men have been drowned in this industry. It is now the practice of some fishermen to wear life vests.

After the dories have been put overboard the steamer cruises among them, and those on board keep a lookout. The system of signals makes it possible to render assistance promptly when needed.

The crew of steamers engaged in the halibut fishery receive 1 cent a pound for the catch, and their labor includes cleaning and icing the fish and doing such work on the fishing ground as may be required. On arriving in port they are expected to discharge the cargo, pack the halibut in boxes, and place them in freight cars; refit the vessel for another trip, taking in ice, bait, stores of all kinds, and performing the necessary work pertaining to the voyage; and stand a regular watch while on the passage either to or from the banks.

The owners keep the vessel in good condition and furnish dories, trawls, buoys, anchors, ice, bait, and food. They take possession of the catch as soon as it is landed, settling with the crew on the return trip.

The captain of a halibut steamer receives $125 a month and a commission of 5 cents a hundred pounds for fish landed; first mate, $100 a month; second mate, $100; engineers (two), from $125 to $150; firemen, two or three generally being employed, $50; cook, $100; deck hands, from two to four, $45.

Gasoline schooners and sailing vessels furnish dories only and take one-fifth of the gross stock of all fish caught. The expenses for food, water, fishing gear, bait, ice, gasoline, etc., are deducted from the remaining four-fifths and the balance equally divided among the crew, including the captain and cook. The master sometimes receives a commission.

When halibut trawls were first introduced on the Pacific coast little or no attention was paid to the kind or quality of bait used for the capture of halibut, it having been found that cod, salted herring, flounders, sculpins, and various other species could be utilized. In a few years, however, fishermen began to notice that the best results were obtained with carefully selected bait, and soon thereafter it was found that halibut would soon bite on "gurry" bait, accepting preferably fresh herring, squid, or other bait. At the present time halibut fishermen of the Pacific coast depend largely upon fresh bait, and their demands are annually increasing. A cold-storage plant at Ketchikan, Alaska, has been supplying a large portion of the halibut fleet with bait during the last few years, and it is very probable

that in the near future other plants will be erected at suitable places along the Alaskan coast adjacent to the fishing grounds. As the fishery increases in importance and grounds lying farther west are resorted to, as is likely to be the case, it will no doubt be found very necessary to establish cold-storage plants or employ fishermen to furnish bait fresh from the water.

There seems to be a far greater loss and waste of fishing gear on the halibut banks of the Pacific than the Atlantic, caused largely by vessels fishing close together. As stated elsewhere, many of the minor grounds are found by means of landmarks, and at times when a fleet of three or four steamers and as many sailing vessels are fishing on a small area, each vessel trying to secure a trip in the quickest possible time, the operations are generally somewhat reckless, trawls being frequently set across and on top of each other to such an extent that it is difficult to haul them. At such times it is not an uncommon occurrence for a dory to lose 5 or 6 lines of trawl and frequently several skates. At other times, on account of stormy weather, especially during the winter months, whole "strings" of gear are lost with the entire catch. It often happens that fishermen are suddenly interrupted in hauling their trawls by a heavy gale, rendering it necessary to cut the gear, which as a rule is seldom recovered, remaining on the bottom together with the catch, which pollutes the ground and undoubtedly has more or less of an injurious effect on the fishery. It is stated by fishermen that several inshore grounds have in this manner been greatly abused.

Until recent years the halibut fishery on the Pacific coast has been confined to comparatively shallow water, 40 fathoms being about the average depth. In the last three years, however, many of the grounds, such as Cape Scott, Hecate Strait, Rose Spit, North Island, and grounds in the channels and bays of southeast Alaska, have shown signs of depletion and the fleet has investigated in greater depths. Trawls set in 70 or 80 fathoms are more difficult to haul than if set in shallow depths, especially if there is a strong tide running, as is frequently the case on shore grounds. Until eastern fishermen engaged in the halibut fishery on the Pacific coast a depth of 100 fathoms was not considered. At the present time fishing is carried on wherever halibut are found, regardless of the depth.

The fishing banks of Canada near the British Columbia coast are situated between Prince of Wales Island, Alaska, and Cape Flattery. They include the shallow waters along the Pacific coast reaching from the land offshore to where the depth is 1,000 feet, a width of from 15 to 40 miles; also the shoaler parts of the great inlets that extend into the continent at Queen Charlotte Sound between Vancouver and Queen Charlotte Islands, and those between Queen Charlotte Islands and Prince of Wales Island extending inshore to where

the distance from land is less than 5 miles and in a few places is within 2 miles.

These fishing banks thus surround the Queen Charlotte Islands, beginning at a point outside 20 miles south of the northwest end and continuing in through Dixons Entrance and southeasterly through Hecate Strait to and around the west and southwest sides of Vancouver Island. Only a small proportion possesses any great value for fishing and those areas are for the most part more than 3 miles from land. They have been found usually after diligent search, and have been known to supply to the fishermen millions of pounds from a single spot.

One of these places is near the west end of Queen Charlotte Islands, an area 1 mile wide and 6 miles long, which was frequented from 1906 to 1909; little has been found there since. One place off Naden Harbor, 2 miles wide by 6 miles long, was frequented from 1905 to 1908; very little has been found there since. One place near the north point of Queen Charlotte Islands, 5 miles wide, 15 miles long, frequented from 1895 to 1908, and undoubtedly the most prolific spot of halibut fishing ground in the world, has not since 1908 produced any great quantity, although when first visited the fishing was always good except, perhaps, during a period of two or three weeks at a time each year in June and October.

The first ground discovered at the west end of Banks Island, an area 3 miles wide and 10 miles long, was frequented from 1892 to 1909 with varying success, usually best during April and August. It is very rarely visited now.

The largest place on the coast, 10 miles wide and 25 miles long, and reaching from Skiddigate Inlet southward along the east side of Queen Charlotte Islands, lies 4 to 14 miles from land, except at Reef Island point, where it passes about 2 miles from shore toward the east end of Banks Island. This area, which has produced the best quality of fish taken, seems nearly exhausted. Very good catches were made on the eastern part in August, 1911, but they were not equal to the catches made when first discovered in 1903.

Another spot near Queen Charlotte Sound, discovered in 1903 and called Goose Island Bank, reaches from 10 to 50 miles southwesterly from Goose Island, which is on the continental side of Hecate Strait. It is a bank spreading over an area of 20 by 30 miles, and since its discovery in 1903 has furnished an abundance of fish of small size, averaging in weight from 9 to 18 pounds each, not considered desirable for shipping long distances, but otherwise of good quality. This bank still furnishes its usual catch in July and August.

These are all the known spots of value on the British Columbia coast until Cape Scott is reached. The bank at the west end of Vancouver Island near Cape Scott and those near the ocean side of

Vancouver Island have been frequented by halibut fishermen since 1888 and are still visited, but with less success. There have been millions of pounds taken from near Cape Scott and occasionally from small spots which have been located along the shores of Vancouver Island, where good fishing would be found lasting sometimes several weeks.

The banks stretching from the Straits of Fuca southward 50 miles from Cape Flattery and westward to those off the coast of Vancouver Island are a continuation of those along the coast of Vancouver Island and the conditions found there are about the same. These Flattery Banks have been fished on since the beginning of the halibut fishery on the Pacific coast, have produced a greater quantity for their size than any other ground, and are still frequented between January and July, after which the quality of the fish found there is poor; and the better fishing is farther north.

This enumeration of the most productive spots for halibut fishing does not include those situated off of the coast of Alaska, which have not been operated on so long or so extensively as those of British Columbia. All the Alaska grounds are situated on the great shelf or continental plateau which extends from the shores of the continent under 50 to 150 fathoms of ocean, a distance of 15 to 50 miles from land to where the embankment suddenly deepens to 1,000 or 1,500 fathoms and the grounds become muddy.

The halibut industry is carried on mainly from Vancouver, British Columbia, and Seattle, and in 1911 the halibut fleet on the Pacific coast consisted of 13 steamers and 58 sail and power vessels. The parties operating from Vancouver represent the wholesale dealers in fish at New York and Boston operating in the West under the name of New England Fish Co. and the Canadian Fisheries Co. (Ltd.). This combination took up the industry after the failure of the pioneers to secure a profit, and by reason of their large trade combined were able to dispose of the product at profitable rates. They employ under the New England heading three steel steamers designed for the business of an average value of $75,000 each (with outfit), built and registered in the United States. The catch of fish is landed in Canada in bonded warehouses and shipped in bonded refrigerators via Canadian Pacific Railroad to Boston and New York, where it is admitted free of duty as product of American fisheries; if any part of the product is sold in Canada, a duty of one-half cent per pound is paid.

Under the name of the Canadian Fisheries Co. (Ltd.), this combine has two steel boats, bought in England (secondhand) and valued at about $25,000 each, the cargoes of which are landed free in warehouses in Canada and sold as product of Canadian fisheries there without the payment of duties in Canada; if any part of the catch of these

boats is shipped to the United States market as product of Canadian fisheries, a duty of 1 cent per pound is to be paid United States Customs Service.

As portions of every cargo are unsuitable for shipping long distances, it is important that a market be found in Canada near Vancouver.

These two companies operate, in connection with their steamers, 60 to 70 small fishing boats, or dories, with two men in each, and 300 miles of fishing lines, and about 20 operatives at their warehouses in Vancouver, British Columbia. The combined product of the five steamers has been about 16,000,000 pounds of fish yearly. In addition, this company has a large cold-storage plant and warehouse near Ketchikan, Alaska, where it receives from its own steamers and other fishing craft something like 2,000,000 pounds yearly, which are transshipped (mostly frozen) to Seattle or Vancouver and in refrigerator cars to eastern markets. About 40 fishing craft, of 15 to 40 tons register and belonging in Seattle and southeastern Alaska, bring and sell their catches to this company at Ketchikan during a part of the time.

Five steamers of an average value of $25,000 each (with outfit) are operated by the firms in Seattle and, in addition, one steamer and one or two power craft are operated from Tacoma. The fishing firms also operate gasoline power boats and about 54 power craft are operated independently from Seattle and Tacoma. During the winter months, or between September and April, about 40 of these craft operate in southeast Alaska waters, and, in connection with the power fishing craft of southeast Alaska, ship their catches by the steamers plying in winter between Juneau, Alaska, and Seattle. An average of three small boats with two fishermen in each is carried on the power and sail craft, of which there are 88 altogether. The aggregate of fishermen so engaged from Seattle and southeast Alaska is 600, in addition to the crews employed on the steamers, or altogether 1,060 men. The Scandinavian race predominates.

The banks of southeast Alaska are likely to become valuable as soon as a method is perfected for handling the catch so that it will reach the consumer in satisfactory condition for food. This will greatly increase the importance of the fisheries of the Pacific coast and will stimulate the development of other industries which may be established in connection with fishing.

PRELIMINARY EXAMINATION OF HALIBUT FISHING GROUNDS OF THE PACIFIC COAST.

By A. B. Alexander.

The decreasing supply of halibut reported on some of the Pacific banks which were formerly fished with profit, and the marked falling off in 1909 and 1910 in certain localities, alarmed the fishermen and caused a request to be made of the Bureau of Fisheries for an extended practical investigation designed to reveal the possibilities of certain banks lying west of southeast Alaska and not hitherto fished for halibut. Nearly all the grounds off the coast of central and western Alaska, including banks in Bering Sea, had previously been investigated by the steamer *Albatross* for cod, but no special effort had been made to ascertain the abundance of halibut, although fish of this species were frequently taken on hand lines from the ship and on trawls set for cod.

Vessels employed in the cod fishery have at times reported taking incidentally considerable quantities of halibut on Albatross, Portlock, Sannak, and other banks. Pelagic sealers also have reported catching halibut on various banks between Middleton Island and Unimak Pass. Trials of this kind, however, furnished little knowledge as to the abundance of halibut in any particular locality or the extent of ground where good fishing might be expected. Beyond the vicinity of Kodiak, Yakutat, and a few other places along the coast, fishermen possessed little authentic knowledge of halibut grounds.

On May 25, 1911, the steamer *Albatross*, Commander Guy H. Burrage, United States Navy, commanding, left Seattle, Wash., fitted with necessary fishing apparatus, such as halibut trawls, hand lines, dories, etc., for making an investigation of halibut banks in Alaskan waters. In addition to the regular crew there were four practical halibut fishermen, Harry Greenwood, Chris Jachobsen, J. F. MacDonald, and G. W. Friis, who during the cruise were under the direction of Capt. H. B. Joyce, of Seattle, a pioneer in the halibut fishery of the Pacific coast, who for a number of years had been in charge of steamers belonging to the New England Fish Co., of Vancouver, British Columbia, and who had been instrumental in calling atten-

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tion to the need of an investigation of the fishing grounds of Alaska hitherto not fished for halibut.

After coaling at Comox, British Columbia, the *Albatross* went to Ketchikan, northward through Wrangell Narrows, Frederick Sound, Chatham Strait, touching at Killisnoo, thence through Icy Strait into Cross Sound by Cape Spencer, from which point a course was shaped for Portlock Bank, latitude 58° 20′ 00″, longitude 150° 30′ 00″ W. Here a "flying set" was made as a test, it having been reported that a vessel had taken a considerable number of halibut on hand lines while drifting over this ground.

From this position the ship continued in a westerly direction over Portlock Bank, across the mouth of Cook Inlet into Shelikof Strait, following the coast line in a southerly and westerly direction as far as Unimak Pass, in which vicinity was the most western point in the halibut investigation. The work was begun in this locality instead of on more eastern grounds in order to take advantage of the pleasant weather which generally prevails here in June and July, but is followed by storms during a period favorable for fishing on Albatross, Portlock, and other banks farther east.

In order to make a fair test of the commercial value of the halibut banks covered by the *Albatross* as compared to those of southeast Alaska and other grounds where extensive fishing has been carried on, it was thought advisable to use the same kind of bait (salted herring) that was used in developing those grounds, and this was done in the majority of trials made.

The halibut caught during the investigation average about 20 pounds. The largest fish were taken on grounds east of Albatross Bank, and the largest individuals were found off Dick Bay, Marmot Bay, in and off Prince William Sound, Portlock Bank, and on grounds lying between Cape St. Elias and Yakutat Bay.

LOCALITIES EXAMINED.

Ketchikan.—The *Albatross* arrived at Ketchikan May 31, and there learned from local fishermen that during the past season a considerable quantity of halibut had been caught off Kelp Bay, on muddy bottom, which is looked upon as an unusual occurrence.

According to Capt. Joyce, a good halibut ground lies 25 miles southwest of Coronation Island, on which many large fares in the last two years have been taken. Another ground about 25 miles southwest from Forester Island has supplied several large cargoes, and 40 miles southwest by west from the island a "spot" has recently been located on which halibut are plentiful at certain seasons.

Killisnoo.—On the evening of June 2 skates of halibut trawl were set off Killisnoo in the harbor in 75 fathoms of water. This set was

made more for the purpose of getting a portion of the gear in working order than for testing the resources of the ground, the area of ground, kind of fish generally found here, and their abundance being already known. The Indians of this locality have always resorted to this spot of ground for their supply of halibut, and for the last 15 years commercial fishermen have occasionally fished in this region.

At times halibut are quite plentiful in this particular locality, but not sufficiently numerous to attract vessels operating a large amount of gear; neither is the ground large enough for more than one or two small vessels at a time. Small boats and canoes at the proper season make good catches.

On the trawls, which had remained set overnight, were found 34 black cod, 7 turbot, 8 rockfish, and 10 ground sharks. The absence of halibut was no doubt due to there being no herring or salmon present, it being too early in the season for those species. During the run of herring and salmon, which occur later in the season, halibut are fairly abundant.

Leaving Killisnoo, the *Albatross* sailed out to sea through Icy Strait and Cross Sound. Fishing for halibut has been carried on in Icy Strait by white fishermen about 15 years, at first chiefly during the winter months, salmon-cannery steamers being employed. In later years small craft engaged in the fishery at various seasons, and in recent years a considerable fleet has fished in this region. Near Cape Spencer two small halibut schooners were seen engaged in hauling their trawls, several of the dories having good catches.

Portlock Bank.—On the morning of June 5 we arrived on the eastern edge of Portlock Bank and made several soundings, ranging from 58 to 67 fathoms. A school of orcas came close to the ship, their movements indicating that they were in pursuit of prey. A considerable number of petrels, auks, and other species of bird life were also usually observed on fishing banks.

Two skates of halibut trawl baited with salted herring were set in 38 and 40 fathoms of water, on hard sand and gravelly bottom; latitude 58° 20′ 00″ N., longitude 150° 30′ 00″ W. The trawls were set 2 miles apart. At the end of one hour and twenty minutes they were hauled, the first taking 7 small halibut and 15 cod, the halibut averaging a little over 5 pounds in weight and 22 inches in length. On the second trawl there were found 21 halibut, averaging 16 pounds in weight and 29½ inches in length, and 25 small cod. The largest halibut weighed 36 pounds, length 42 inches. During the time the trawls were being set and hauled 54 cod and 1 small halibut were caught on hand lines from the ship. The cod ranged from 18 to 36 inches. The result of this trial would indicate that a halibut steamer would meet with considerable success on this ground. A vessel

operating the usual amount of gear carried by fishermen would, in a few days, naturally attract large halibut, as the bait which falls off and is "shacked" from the hooks generally has that effect if any large fish are near. The position occupied was near where a sealing vessel had reported taking a considerable number of halibut on hand lines and by "jigging." About 3 miles from the ship numerous whales and birds were observed.

During the night the *Albatross* steamed through Shelikof Strait. The following morning, the weather being thick and stormy, it was decided to seek shelter in Halibut Bay, southwest end of Kodiak Island. At this anchorage cod were quite plentiful, 58 being caught on hand lines in a comparatively short time.

Chignik Bay.—We arrived at Chignik Bay on the morning of June 8. The season was backward, the weather cold, the mountains and surrounding country covered with snow, in many places to the water's edge. The salmon cannery men were making preparations for the season's catch, driving piles for the traps, hanging web, making cans, unloading various material from the ships, and putting the cannery machinery in order.

The ship remained at Chignik Bay until June 26 for the purpose of making a survey of Chignik Lakes. On arriving at Chignik it had been contemplated to land the surveying party, and have the vessel engage in the halibut investigation on Albatross Bank or some other ground adjacent. No time, however, was lost by remaining in the harbor, as no satisfactory results could have been obtained owing to the unfavorable weather during that period.

Fishing parties frequently visited the ground lying off the mouth of the bay, with fairly good results, the various trials resulting in 423 cod, 29 halibut, 3 turbot, and 7 sculpins. The depth of water ranged from 20 to 26 fathoms; character of the bottom, sand, rocks, and small pebbles. The cod were of good quality, but comparatively small. The halibut were also small, the largest single individual weighing 12 pounds; general average, 8 pounds. Both hand lines and trawls were used. On several occasions more fish were taken on the hand lines than on the trawl. This frequently happens at certain times on all grounds, especially where there is an abundance of starfish, as was the case on this ground. The baited hooks of the trawl which lie on the bottom attract the starfish and are preempted by them.

While halibut and cod in the immediate vicinity of Chignik are not plentiful viewed from a commercial standpoint, yet they are sufficiently abundant to more than supply all local demand. It is not uncommon to find halibut in the salmon traps here during the salmon season, and occasionally large individuals are taken in the harbor

and lagoon close to the wharves, being attracted from offshore grounds by the offal from the canneries.

The harbor is not well suited for fishing vessels, it being exposed to easterly winds; the holding ground is also poor. In the spring of 1911 a cannery ship dragged ashore and was a total loss.

The *Albatross* left Chignik June 27, steaming through Unga Strait, and passed a cod fisherman off Cape Pankof bound into Bering Sea. There seems to be no reason why the San Francisco and Puget Sound cod fleet should confine their fishing wholly to the Bering Sea region, there being good cod grounds on the banks lying off Kodiak Island, the Shumagin and Semidi Group, where the quality of cod is said to equal those found farther north. It is stated that fish in the localities mentioned are not numerous; but it is safe to say that the small vessels of the fleet, and many of the large ones, would find little difficulty in obtaining cargoes as quickly as on banks in Bering Sea.

Akun Island.—On the morning of June 28, having arrived at Akun Island, situated on the west side of Unimak Pass, four halibut trawls, baited with salted herring, were set at the mouth of Akun Bay at intervals of 1 mile apart, in depths varying from 41 to 74 fathoms; character of bottom, fine gray sand. The trawls remained down 1 hour and 20 minutes, the result being 5 halibut, 115 cod, and 7 sculpins. The average weight of the halibut was 10 pounds; average length, 28 inches; maximum weight and length, 16 pounds and 34 inches. The cod were evenly distributed among the dories, showing that the ground had a considerable number of cod on it, and with fresh bait and a trial lasting several days fair fishing might be expected. The cod were larger than those taken at Chignik, several weighing 25 pounds; the largest weighed 30 pounds. The hooks brought up a variety of marine growth, starfish, mussels, sea urchins, and live shells covered with sponge. Trawls set any distance from the eastern side of Akun, or a mile or more outside the mouth of Akun Bay, would come in contact with the strong tide sweeping through Unimak Pass. It is very doubtful if the halibut fishery could be carried on here with any degree of success, except on the slack of the tide, which is of short duration. It would not be possible to haul a trawl at other times.

Lost Harbor.—This harbor is situated on the west side of Akun Island and affords a good shelter from easterly winds. For the purpose of making a trial in this locality the ship came to anchor at 3 p. m., and a skate of trawl was set off the mouth of the harbor; depth 20 fathoms, rocky bottom. The catch was 2 halibut, weighing 4 and 8 pounds, respectively, and 10 cod; the cod averaged 10 pounds. The result of this trial would not indicate halibut to be plentiful at this season. A trial later in the year, at the time salmon

appear, might prove more successful. It is quite safe to assert that cod in this vicinity are sufficiently abundant to furnish a supply for a large shore plant if operated properly.

Akutan Harbor.—In the evening we steamed across Akutan Bay and anchored in Akutan Harbor. On our way into the harbor a dory was dropped and a trawl set off the mouth in 27 fathoms of water, on rocky bottom, where it remained one and one-half hours. The catch was 1 halibut, weighing 4 pounds, and 12 cod.

While steaming across Akutan Bay a large fishing schooner was sighted through the fog which afterwards proved to be the *Vera*, of Seattle, some of whose crew had been fishing with handlines from dories in and out the mouth of Akutan Harbor while the vessel was taking a supply of water. In two days 4,200 cod were taken—1,500 the first day and 2,700 the day following. That cod were plentiful was indicated by the number taken on the trawl set at the mouth of the harbor.

It was stated by the people living at Akutan Harbor that a whale plant was soon to be erected and a cod station established, each to be conducted on a large scale. A large steamer was about to be launched at Seattle to engage in the whale fishery, and several motor boats and dories were expected in a few days to take part in the cod fishery. The motor boats are to be used in towing the dories to and from the fishing grounds and performing such work about the station as may be required.

Akutan Harbor for many years has been occupied by the Alaska Commercial Co., of San Francisco, as a trading station, but recently the property was transferred to another company which is to carry on the whale and cod fisheries previously mentioned.

Many humpback whales were observed on the eastern side of Akun Island, and quite a number in Akutan Bay, which separates Akun and Akutan Islands. Whale birds were numerous and other sea birds plentiful.

While no large body of salmon visit Akutan, yet enough are taken by the natives for local demands. It has also been the custom of the natives of Unalaska to visit Akutan each season for the purpose of laying in a supply of red salmon, that species being found there in greater numbers than in the streams of Unalaska.

North Head.—Leaving Akutan Harbor, the next trial for halibut was made off North Head, where two skates were set in 26 fathoms of water; character of bottom, rocky. On one skate there were taken 1 halibut, 38 cod, 2 skates, and 2 sculpins. The second skate caught 12 cod, 2 turbot, and 2 sculpins. The halibut weighed 5 pounds and measured 23 inches. The cod were large, such as those found on the offshore grounds. There was marked absence of birds or other forms of life which would indicate prolific ground.

The tide was not so strong as on the east side of Akun Island, and in consequence the trawls were easily hauled. Had they been set a mile or more from the shore a strong tide would have been encountered.

In the afternoon, June 29, we anchored off Dutch Harbor, Unalaska, and after coaling left on July 5 for Bering Sea.

Slime Bank.—Off Akutan Pass we passed through immense flocks of whale birds. Many of the flocks covered several miles in length and from one-half to 1 mile in width. Throughout the summer months these birds may be found in great numbers in the vicinity of Akun and Akutan Islands and in Unimak Pass, and they are also numerous along the coast of Alaska wherever whales are present in considerable numbers. The amount of food necessary to supply them must indeed be large, and as more birds are found in Bering Sea and in the passes leading into it than elsewhere the waters must be teeming with minute animal life and small surface fishes sufficiently abundant to supply both whales and birds.

Our first set made in Bering Sea, and probably the first halibut trawl ever set in this sea, was made on the morning of July 6, with two trawls about one-half mile apart in 43 fathoms of water; character of bottom, black gravel; Cape Lapin bearing southeast, 16 miles distant.[a] The result of these sets, lasting 54 minutes, was 54 cod, 1 turbot, 1 skate, and a small crab. Only a few of the cod were brought on board. The maximum weight was 32 pounds and 39 inches in length; minimum, 12 pounds and 29½ inches.

The end of one of the trawls dropped off into 60 fathoms of water, in which depth some of the largest cod were taken. It is stated by most fishermen who have fished on banks in Bering Sea that as a rule the best fish are found farther off shore than where fishing is usually carried on. The reason why vessels confine their operations to the inshore grounds is that the crew are paid by the fish, and smaller fish are found near the shore. In other words, it is to the advantage of the crew to catch no more than they must of the fish over 28 inches in length, the standard measurement of what is termed a "count fish," because large fish fill the hold too quickly.

In the afternoon a set was made in 54 fathoms on sand and gravelly bottom in latitude 54° 53′ 00″ N., longitude 165° 20′ 00″ W., a distance of 22 miles from Cape Sarichef. On account of a strong wind and choppy sea the trawls were hauled after 45 minutes, taking 6 cod.

In previous trials for bottom fish in Bering Sea by the *Albatross* on grounds farther eastward, scattering halibut were taken. Fishermen who make annual trips to Bering Sea for cod report finding large quantities of small halibut on the eastern part of Slime Bank,

[a] All bearings are magnetic. The position of the trials, showing the latitude and longitude and depth of water, were platted by Lieut. Lewis B. Porterfield, U. S. N.

in the vicinity of Amak Islands, close inshore off Black Hill, and in various localities on Baird Bank, in some instances so numerous, according to one fishermen, as to be considered a nuisance. There is no report of large halibut having been taken on the above-mentioned grounds. It is estimated that few will exceed 25 pounds in weight. They are used by the hand-line cod fishermen for bait. Individuals weighing upward of 100 pounds have been reported caught on local grounds off the Pribilof Islands. Owing to unfavorable wind and weather no further trials were made in Bering Sea.

Davidson Bank.—Our next trial was made July 7 off Tigalda Island, the southeast end bearing north, distance 3 miles; depth of water 42 fathoms; character of bottom, gray sand. This ground may be termed the western end of Davidson Bank.

In a set (1 skate) lasting 40 minutes 11 cod, 1 flounder, and 7 sculpins were caught. A strong tide was running against the wind. On this ground strong tides may be expected, it being near Unimak Pass. Immediately following this set one was made on the southern and western edge of the bank 21 miles southeast by east from the last station occupied, in 62 fathoms of water; bottom, fine gray sand; latitude 53° 45′ N., longitude 164° 30′ W. The length of the trial was one hour, resulting in 12 good-sized cod and 1 skate. Had there been halibut in any considerable quantity it is very probable that at least a single individual would have been captured. In localities where halibut are fairly plentiful a skate of trawl in one hour's time usually captures several.

The results of the investigation in the vicinity of Tigalda Island and that portion of Davidson Bank covered would indicate a scarcity of halibut. It is possible, however, that at an earlier or later period they may be found in paying quantities. A diligent search lengthened into an entire season would be required to determine the richness of the ground; but inasmuch as no halibut were caught at the stations occupied we are of the opinion that at this season negative results would have followed a much longer trial.

Sannak Bank.—At 8 o'clock on the morning of July 8 a trawl was set in 50 fathoms; bottom composed of pebbles and rocks; latitude 54° 13′ N., longitude 162° 10′ W., or Seal Rock, off Sannak Island, bearing W. by N. ½ N., 16½ miles distant. The usual time was devoted to this trial, 28 cod, 3 halibut, 1 rockfish, and 1 large octopus being taken. A second dory made a set a short distance from the first, in 43 fathoms of water, and in 30 minutes caught 63 large cod and 2 octopi. The halibut averaged 10 pounds and 30 inches. The cod were extra large, those which were brought on board ranging in weight from 32 to 35 pounds and in length from 29 to 41 inches.

Two large stones came up on one of the trawls, to which was attached a considerable growth of crinoids, a very good indication

that fish are more or less abundant. This ground would be a most excellent place to operate with cod trawls. A vessel fitted with trawls would have little difficulty here in securing a trip in one-half of the time she would need if hand lines were used.

This position was on the edge of the bank, less than 3 miles from the 100-fathom curve, and about 7 miles from where the water suddenly deepens to 211 fathoms, soft, muddy bottom.

The next trial was made in 64 fathoms, rocky bottom, latitude 54° 08′ 30″ N., longitude 162° 11′ 20″ W., Lookout Point, Canton Island, bearing NW. ¼ W. 16 miles distant. Two halibut weighing 7 and 9 pounds, respectively, and 2 red rockfish composed the catch.

From this position the ship steamed east 2 miles and set one skate of trawl, in 45 fathoms of water, rocky bottom. On hauling the trawl it was found that the anchor was caught under a rock, and in trying to clear it the buoy line chafed off, causing the loss of the gear. The trawl having been baited with fresh octopus good results were expected, and a comparison was to be made between salt and fresh bait. This position was also close to the 100-fathom curve and 4 miles from a depth of 435 fathoms marked on the chart.

At 6 p. m. another trial was made on rocky bottom in 47 fathoms, a distance of 34 miles from the previous trial, Pinnacle Rock bearing NW. ½ W., distance 17 miles, or latitude 54° 31′ N., longitude 161° 33′ W. At this station 2 halibut, the combined weight amounting to 15 pounds, 8 cod, and 9 sculpins were caught, a much smaller catch than was expected, the position being on the western edge of the Shumagin Island ground, where large numbers of cod are annually taken. If a cod trawl had been set here it is very probable that a much larger catch of cod would have been taken.

Unga.—A short call was made at Unga, situated on Unga Island, Sunday morning, July 9, the ship anchoring off the mouth of the harbor about a mile from the village.

A cod station has been operated here many years by a San Francisco firm. Fishing is carried on in dories, hand-lines only being used, as at Sand Point and Pirate Cove, Popof Island. The supply of fish comes from local grounds in Popof Strait and at various points off the southern and eastern sides of Unga Island. The fishermen leave the station in the morning, weather permitting, and return in the afternoon. The fish are dressed on shore, salted in large vats, and at the end of the season shipped to San Francisco, where they are dried and prepared in various styles for the market.

From the fishermen on shore we were informed that an attempt at one time had been made to introduce cod trawls, but they proved unsuccessful. In what manner they were a failure we were unable to learn. It is very probable that fishermen were not familiar with this form of apparatus and in consequence could not operate it.

It was learned that halibut are not plentiful in these waters at any time. Scattering individuals are caught in August at the time herring put in an appearance.

It was stated that a considerable body of herring frequently visits Simeonof and Semidi Islands, the first mentioned being one of the Shumagin Group, the second lying about 100 miles to the eastward. A few days previous to our arrival a vessel left Unga fitted with gill nets to engage in the herring fishery at those islands and at other places adjacent where fish were to be found.

Shumagin Bank.—On July 9 a set was made on Shumagin Bank, 19 miles to the southward of Unga, in 40 fathoms of water; character of bottom, sand and pebbles; Mountain Cape, Nagai Island, bearing ENE., distance 16 miles, or latitude 54° 53′ N., longitude 160° 38′ 30″ W. One halibut, weighing 3 pounds and 20½ inches in length, 3 cod, and 2 sculpins was the catch in a trial lasting one hour. From a fisherman's point of view this ground would not be considered of sufficient importance to spend much time upon it, although, as previously stated, a trial made at some other season might yield good results.

The next station occupied was 16 miles farther off shore in 80 fathoms of water; sand and gravel bottom; Mountain Cape, 22 miles distant, bearing N. ½ E., or latitude 54° 34′ N., longitude 160° 24′ W. Better results were obtained here than in the preceding trial, 3 halibut, 16 cod, and 1 turbot being taken. The halibut averaged 10 pounds in weight and 29 inches in length. The cod were of good quality. The catch fell short of expectations, presumably for the reason suggested by the report that a sailing vessel had incidentally caught a considerable number of halibut on this ground while becalmed.

During the night of the 9th a run of 67 miles was made to the eastward, and in the morning the ground was tested in 90 fathoms of water 21 miles ENE. from Simeonof Island, latitude 54° 55′ N., longitude 158° 34′ W.; character of bottom, mud and sand. It had been reported that a good catch of halibut had been taken here on hand-lines by a passing vessel, but a trial of 1 hour and 20 minutes resulted in only 4 cod and 1 skate.

Steaming 27 miles on an ENE. course, we arrived at another position where halibut had been reported plentiful and began setting a "string" of four trawls in separate dories. The first trawl was set on rocky bottom, 48 miles ENE. from Simeonof Island, latitude 54° 53′ N., longitude 157° 48′ W. Two others were set 2 miles apart in a SSE. direction, and the fourth 3 miles from the third, a distance of 7 miles from first dory. The depth of water varied from 48 to 70 fathoms. They remained down one hour and a half, the aggregate catch amounting to 11 halibut and 97 cod. The average weight of

the halibut was 15 pounds, average length 30 inches. Numerous sea birds were present, the first observed since leaving Akutan Pass.

Two other trials were made during the day. The trawls were baited with salted herring and fresh halibut and set 2 miles apart, one in latitude 54° 59′ N., longitude 157° 43′ W., and the other in latitude 55° 01′ 30″ N., longitude 157° 43′ W., on rocky bottom, each in 42 fathoms of water. They were kept down 1 hour and 30 minutes, with a result of capturing 14 halibut, 46 cod, 7 sculpins, and 1 starfish. The halibut averaged 11 pounds in weight and 20 inches in length, the maximum weight of a single individual being 20 pounds. The cod were large and of good quality. The result of these trials would indicate an excellent cod ground, and probably a good halibut ground at certain seasons. Whales and birds were abundant.

Semidi Islands.—On the morning of July 11, at 6.15 o'clock, fishing was begun off Semidi Islands, Lighthouse Rocks 7 miles distant and bearing WNW. ¼ W.; depth 48 fathoms, rocky bottom. At this station one skate of trawl was set, remaining down one hour, on which 1 small halibut and 4 cod were caught.

In the next investigation, which began at 8.05 a. m., Lighthouse Rock bearing W. ¼ S., 10 miles distant, a dory was put over with one skate of trawl and set in 48 fathoms; character of bottom, sand and small rocks. The ship steamed 2 miles on a NE. ¾ N. course and dropped a dory where the water was 49 fathoms deep, after which continued on the same course and put over two more dories at intervals of 2 and 3 miles, in 50 and 53 fathoms. At these stations 23 halibut and 52 cod were caught. The trial lasted 1 hour and 40 minutes. A large number of whales and numerous birds were present, indicating the presence of marine surface life.

The taking of this number of halibut on salt bait in such a short time is somewhat convincing that this region is favorable for a considerable catch of this species. The true value of the ground, however, can be determined only by fishing vessels.

Chowiet Island.—The next trial was made in the vicinity of Chowiet Island, one of the Semidi group, which bore NW. ½ W. 6½ miles. The set was begun in 100 fathoms of water, deepening to 120 on the outer end of the trawl; bottom sandy. There were few, if any, indications of halibut on this spot of ground. Twenty-six cod, 2 skates, and a basket starfish was the catch.

Chirikof Island.—From the position of the last trial the ship steamed 27 miles in a northeasterly direction, and at 6.50 p. m. made a trial 11 miles from Chirikof Island, the north end bearing east. Character of the bottom, dead shells; depth, 40 fathoms. The trawl was kept down 1 hour and 20 minutes, the catch consisting of 2 halibut, 8 cod, and 1 skate. The halibut weighed 9 and 12 pounds, respectively; length, 27 and 29 inches. The considerable number of

dead shells which came up on the hooks indicates, as a rule, poor fishing ground.

Western entrance to Shelikof Strait.—During the night the *Albatross* steamed to the north and eastward, and on the morning of July 12, the weather being foggy, sounded in 114 fathoms of water some 8 or 10 miles to the westward of Seal Rocks, which lie close to the western end of Kodiak Island. Stood inshore 3 miles and sounded in 98 fathoms and later got a depth of 58 fathoms, at which time the fog lifted, Cape Ikulik bearing N. by W. 6 miles distant. In this position a skate of trawl was set baited with salted herring and fresh cod, chiefly the former. After 1 hour and 40 minutes the haul resulted in 7 halibut, 16 cod, 6 skates, and 2 turbot. The halibut were taken on the hooks baited with salted herring and were small, the largest weighing 11 pounds, the smallest 6 pounds. There was a considerable quantity of mud, sand, and small rocks on the trawl anchor. Whales were very plentiful. The number of halibut taken here does not compare favorably with trials of equal length on most grounds in southeast Alaska, although it might be possible for a vessel operating a quantity of trawls to secure a trip in a comparatively short time.

A run of 12½ miles in a southeast direction brought the ship in the vicinity of Low Cape, situated close to the southwest end of Kodiak Island, in 34 fathoms of water, rocky bottom, the cape 8 miles distant, bearing E. by N. At 12.30 p. m. a second trawl was set 1 mile S. by E. ¾ E. from the first, in 52 fathoms, the character of the bottom the same as at the first station.

The first trawl remained set one hour, and from it were taken 13 halibut, 9 cod, 1 skate, 4 sculpin, and 1 octopus; from the second, 8 halibut, 13 cod, 1 skate, and 1 sculpin. The halibut taken by the first dory averaged 11¾ pounds, and that by the second 14 pounds, a higher average than for any previous catch during the cruise.

It is very evident that a considerable body of halibut inhabit this ground. In the opinion of Capt. Joyce, and also the four practical fishermen on board, a halibut steamer well equipped with trawls would take 50,000 pounds of halibut in one day's fishing. The indications here are as good as in many places on southeast Alaska and Queen Charlotte Island grounds, where fishing has been carried on for the last 18 years and millions of pounds of halibut caught.

Cape Alitak.—The dories having been hoisted, a course was shaped for Cape Alitak, and at 4.55 p. m. a set was made with one skate of trawl in 27 fathoms; bottom, shells and small rocks, the cape bearing NE. by N. 10 miles distant, Cape Trinity 14½ miles distant and bearing ENE. The trawl was baited with salt herring and fresh cod; trial, 1 hour and 15 minutes. Here the catch consisted of 4 halibut,

11 cod, 2 skates, and a basket starfish. The halibut were smaller than those captured in the previous trial, the average weight being $8\frac{1}{4}$ pounds and length $26\frac{3}{4}$ inches. Another dory set a trawl $\frac{1}{2}$ mile E. by N. $\frac{1}{2}$ N. from the first one, in 40 fathoms; character of the bottom, blue clay; length of trial, 1 hour and 30 minutes; the result being 3 halibut, weighing 9, 10, and 12 pounds, respectively, 3 skates, and 1 turbot.

Evidently halibut on this ground were scattering as compared to the former spots investigated in this region, but as good and poor grounds are frequently found close together, it is not at all unlikely that a mile or more in any direction might reveal favorable conditions.

Two whale steamers were seen steaming at a moderate rate of speed, and one of them fired several times at whales, of which many were present. On this ground and on the entire coast of Kodiak Island, from Marmot Bay to Cape Alitak, are usually found, during the summer months, a large number of humpback whales.

Alitak Bay.—Lazy Bay, situated on the northern side of Alitak Bay 4 miles from the entrance, offers good shelter for vessels fishing on grounds in the vicinity of Seal Rocks, Low Cape, Cape Alitak, or Tugidak Island.

Albatross Bank.—This bank covers an area of about 4,000 miles, and extends practically from the western end of Portlock Bank along the southeastern side of Kodiak Island to Trinity Islands. Near the coast it has for many years been resorted to by local fishermen for cod. Halibut have incidentally been caught on various parts of the bank, but no systematic search has been made for them, as there is no local demand sufficiently large to warrant the expense of an outfit of proper fishing gear.

In the evening of July 12 the vessel passed through the channel between Cape Trinity, Tugidak, and Sitkinak Islands, and headed south and eastward under slow speed. At 4.50 a. m., arriving at the place for the next trial, a dory was put over on the western part of Albatross Bank in latitude 56° 21′ N., longitude 153° 15″ W., where one trawl, baited with fresh octopus and salted herring, was set in 18 fathoms of water; hard, rocky bottom. At the time of setting the trawl a very strong tide was running to the northeast; weather foggy, but clearing later and affording an opportunity to locate our position.

At the expiration of one hour the trawl was hauled, but soon after breaking out the anchor the ground line parted, and it was necessary to go to the other end. Here again, however, the line parted a few hooks from the end. On the few hooks that were saved six cod were caught. On this spot of ground the bottom is undoubtedly too rocky and rough to operate trawls. Hand lines probably would obtain much better results.

From this position the ship steamed 29 miles in a N. ½ E. direction, and at 10.15 a. m. arrived at latitude 56° 36′ N., longitude 152° 56′ W.; depth, 44 fathoms; character of the bottom, sand and gravel. A trial lasting 1 hour and 20 minutes with one skate of trawl resulted in 4 halibut, 28 cod, 1 skate, and 1 sculpin. The halibut were small, averaging 5½ pounds.

In latitude 57° 00 N., longitude 152° 21′ W., 2 halibut, 17 cod, and 2 skates were taken on a trawl which remained set 1 hour and 30 minutes; depth, 45 fathoms; bottom, rocky. The cod were of medium size; the halibut averaged 15 pounds, one individual weighing 22 and the other 8 pounds. This position was 32 miles from the previous trial and the last one made for the day.

Portlock Bank.—This bank is a continuation of Albatross Bank. Its western boundary begins at about 152° west longitude and in the latitude of Ugak Bay, extending in a northerly and easterly direction a distance of about 120 miles and covers an area of nearly 7,000 square miles, all of which is within the 100-fathom mark. Were that portion of the bank included on which 175 fathoms or less are found, its size would be increased to about 8,500 square miles.

On July 14 work began at 5 a. m. Sounded in 42 fathoms; character of the bottom, shells and small rocks. This position was 44 miles in a N. by E. ¼ E. direction from the previous station occupied. It is quite evident that cod were much more plentiful here than halibut, 19 of the one and only 2 of the other being taken.

Thus far cod have predominated in the various trials made on this bank. That halibut may be found at times in commercial quantities on that part visited by the *Albatross* is very probable, but it is thought that cod will be found on all parts in greater numbers.

In a trial 17 miles from the last station, latitude 57° 46′ N., longitude 151° 27′ W., 3 halibut and 13 cod were caught in 34 fathoms, rocky bottom. The fishermen reported that one end of the trawl was in nearly 100 fathoms of water. Several hydroids were brought up on the trawl. In the evening the *Albatross* anchored off Kodiak Harbor.

The trials made on Albatross Bank do not bear evidence that halibut in large numbers may be looked for at this season. A few trials on a bank at a certain season is hardly a fair test of the ground; at an earlier or later date results might be satisfactory. Therefore it is recommended that should halibut fishermen visit this ground they give it more attention than the time at our command would permit.

Kodiak.—The Alaska Commercial Co. having abandoned most of the stations in Alaska, which at one time gave employment to a large number of natives, several former employees are contemplating establishing a cod-fishing station at Kodiak. It is understood that several

vessels have been negotiated for to engage in the cod and halibut fisheries, the necessary dories, fishing gear, etc., having already been purchased. It was also stated that a large three-masted schooner was to be fitted for freezing halibut, salmon, and other fish, and it was subsequently learned that the schooner obtained a cargo. The cod and halibut were taken off the eastern end of Kodiak Island, western edge of Portlock Bank.

Vessels fishing on Portlock or Albatross Banks or any of the local grounds off Kodiak Island should not find it difficult to obtain a supply of bait. The various species of low-grade salmon which are sometimes used for bait are obtainable in their season at different parts of the island.

At times herring are said to be plentiful in Victoria and Uganik Bays, situated on the northern part of Kodiak close to Kupreanof Strait. Herring are also found in Marmot Bay.

Salmon are easily captured in drag seines, and herring in the same manner when found in bays. Gill nets set on the banks and in harbors and bays might also be the means of adding to the bait supply. The numerous birds generally observed on the fishing grounds in this region strongly indicate the presence of surface fish, among which are herring.

Fishermen, as a rule, are not inclined to spend much time in search of bait or make much effort to catch it, provided it can be purchased at a reasonable price, it being considered more economical to purchase than to catch it. Should a portion of the halibut fleet find it profitable to fish on banks off the coast of central Alaska, stations supplying bait would doubtless be established within a short time.

On July 17 the investigation was continued, the first trial being made broad off Chiniak Bay, 15 miles in a S. by W. direction from the position of the last trial, on July 14. The set was made in 54 fathoms on rocky bottom, a distance of 12 miles from Cape Chiniak, which bore SW. $\frac{3}{4}$ W. The trawl was allowed to remain down 1 hour and 30 minutes and captured 9 halibut, 11 cod, and 5 turbot. The largest cod weighed 27 pounds; halibut averaged $9\frac{1}{2}$ pounds in weight and $28\frac{1}{2}$ inches in length. One individual measured 36 inches and weighed 22 pounds; the smallest 24 inches and 5 pounds.

The ship ran $14\frac{1}{2}$ miles toward Ugak Island and sounded in 40 fathoms; broken bottom, composed of shells, pebbles, gravel, and mud, the island bearing SW. $\frac{1}{2}$ S.; distance, 10 miles. One trawl was set, and 1 mile SW. by W. from the first dory a second set was made in 38 fathoms on hard bottom, composed chiefly of small rocks. The first trawl remained down 1 hour and 15 minutes and the second 1 hour and 40 minutes, the combined catch amounting to 10 halibut, 15 cod, 9 sculpins, 2 skates, and an octopus. The halibut were small,

ranging from 3 to 7 pounds. In the immediate vicinity of both of these stations whales were plentiful, apparently feeding upon surface life of some kind. The result of these two trials did not indicate a prolific halibut ground.

On July 18 one dory left the ship at 4.50 a. m. and made a set about 30 miles from the last station in 72 fathoms on small rocks and pebbly ground, latitude 57° 12′ 30″ N., longitude 151° 12′ 00″ W. The economic species caught were 9 cod, 1 black cod, and 1 Attu mackerel. On the ground were several whales playing around the dory and ship. Attached to some rocks brought up on the trawl were several crinoids, indicative of what is termed by fishermen "good bottom."

The Attu mackerel was accidentally taken, hooked in the eye, apparently indicating that a school of this species was passing under the dory at the time the trawl was being hauled, and this fish was caught as the hooks were pulled rapidly through the water. So far as known, there is no previous record of mackerel being taken any considerable distance from the shore. Our position at the time was 37 miles from Narrow Cape, which is situated at the northern entrance of Ugak Bay, Kodiak Island, and 5½ miles from the 100-fathom curve—9½ miles from where the bottom drops off into profound depths. Mackerel have generally been observed and caught near ledges and kelp patches along the coast.

During the day two other trials were made on the southern and eastern edge of the bank 14 miles apart, the first 22 miles from the last position occupied. At 1.35 p. m. a sounding was taken in 62 fathoms. The arming on the lead showed the bottom to be composed of coarse sand. At 1.45 p. m. a skate of trawl was set, baited with fresh cod and salt herring; latitude 57° 27′ 00″ N., longitude 150° 40′ 00″ W. The length of this trial was 1 hour and 40 minutes, during which time the ship steamed 5 miles on an east course and sounded in 160 fathoms, getting no bottom.

On returning to the dory it was found that the trawl had taken 3 halibut and 33 cod. The average weight of the halibut was 9⅓ pounds, average length 38⅗ inches. The five cod that were saved averaged 20 pounds and 36 inches. They were excellent in quality, as were the others that were removed from the hooks. It is very probable that a trawl-line fishing vessel would soon secure a fare of cod in this region.

At 5.50 p. m., in 55 fathoms, rocks and sandy bottom, latitude 57° 42′ 00″ N., longitude 150° 42′ 00″ W., a trawl was set and 3 halibut, averaging 13 pounds and 30 inches, and 32 cod were caught, the trial lasting 45 minutes. The trawl, as in the previous trial, was baited with salt herring and fresh cod. There seemed to be as many cod taken on the salt bait as on the fresh. This was also true of the halibut.

Marmot Island.—During the night the ship covered a distance of 41 miles in the direction of Marmot Island. This island lies off the eastern end of Afognak Island, the two being separated by Marmot Strait, which is 3 miles wide and 10 miles long.

On the morning of July 19 a trial was made in 55 fathoms, Marmot Cape bearing west 5 miles distant; character of the bottom, dead shells. On this ground the catch consisted of 2 cod and 2 skates. The true character of the bottom in most cases was not determined until the trawl had been hauled. A deep-sea lead having an arming of tallow brings up a sample of the bottom, covering a diameter of 1½ inches. The lead may strike on some particular spot composed of sand or gravel, while the general character may be broken shells and mud, on which little or no marine life could be expected. As a trawl covers a considerable stretch of ground, it more accurately determines the character of the bottom than the ordinary process of sounding.

At 11.10 a. m. another trial was made near the south side of Izhut Bay, Afognak Island, a distance of 19 miles west of our former position, on rocky bottom in 30 fathoms, the inner end of the trawl being one-half mile from the shore, Pillar Cape, situated on the north side of the bay, directly at its mouth, bearing NE. ¼ E. 5 miles distant. At 3 p. m. a third test of the ground was made off Narrow Strait, 3.8 miles from South Point, Spruce Island, which bore W. ½ S. The combined catch at these stations was 52 cod, 4 halibut, 1 rockfish, and 13 sculpins. The average weight of the halibut was 18½ pounds, average length 25½ inches. One weighed 45 pounds and was 43 inches in length. The cod were fairly large and of good quality.

The ground covered on this day does not indicate that a large body of halibut might be expected at this season, although it is reported by local fishermen that at times they are to be found in paying quantities, more especially in the vicinity of Marmot Bay. It is quite evident that cod at most seasons are quite plentiful.

At 5 a. m., July 20, in latitude 58° 06′ 30″ N., longitude 151° 00′ 00″ W., a trial was begun in 65 fathoms of water, on coarse sandy bottom, lasting 45 minutes; 1 halibut and 11 cod taken. The result was not as satisfactory as expected, although the character of the bottom was such as should attract halibut.

At 11.55 a. m., about 14 miles from the position of the last station, in latitude 58° 03′ 00″ N., longitude 150° 32′ 00″ W., 8 halibut, 13 cod, 2 rockfish, and an octopus were caught; depth, 50 fathoms; rocky bottom. The halibut averaged 13¾ pounds and 33 inches. There was very little food in their stomachs. The eggs of one had the appearance of being well developed. The ground bore evidence of being rich in marine growth, several clusters of crinoids being taken on the hooks of the trawl. In this locality the indications are

that the ground is prolific and a large catch of halibut could be obtained in a short time.

At 4.18 p. m., in latitude 58° 16′ 00″ N., longitude 150° 20′ 00″ W., a set was made in 48 fathoms; bottom, pebbles and rocks. At 4.30 put over the second dory 1½ miles NW. by W. from the first position and made a set in 52 fathoms; character of the bottom, broken shells. The first trawl remained down 1 hour and 5 minutes, and the second 1 hour and 20 minutes. The catch of the first consisted of 6 halibut, 14 cod, and 2 skates; and the second 7 halibut, 16 cod, and 2 skates. The halibut at the first station averaged 22 pounds in weight and 32 inches in length; the largest weighed 40 pounds, having a length of 42 inches. Those caught at the second station averaged 18 pounds and 33 inches. This ground is situated 10 miles S. by E. ½ E. from the "spot" where the first trial was made on the afternoon of June 5. In this region there is every evidence of a fishing ground of considerable importance.

On July 21 the *Albatross* anchored off the town of Seward, Resurrection Bay, a distance of 112 miles north of the position of the last trial.

Blying Sound.—The next trial was made on the morning of July 24 at the mouth of Blying Sound and just north of Aialik Bay, in 50 fathoms, near the south end of Cheval Island, on rocky bottom. The trawl remained set 1 hour and 20 minutes, in which time 3 halibut, 7 cod, and 2 turbot were captured. The result of this trial did not indicate the presence of a large body of halibut. It is possible that the glacial water discharged from Resurrection and Aialik Bays may prevent halibut from approaching this part of the coast; although in Icy Strait, southeast Alaska, where there is a large quantity of glacial water coming from Muir and Brady Glaciers, halibut are very plentiful at different periods.

In a trial lasting one hour, in 57 fathoms, rocky bottom, off the south side of Seal Rocks, which lie 8 miles off the west side of Aialik Bay, 1 halibut weighing 7 pounds, and 1 skate were caught. As there seemed to be nothing of importance in this locality the ship was headed for Point Gore, 49 miles south and west of Seal Rocks. The following morning, July 25, on account of stormy weather, an anchorage was made in Sunday Harbor, where we remained until the morning of July 27.

Sunday Harbor.—This harbor affords good anchorage for large vessels. There is very little obstruction at its entrance. The northern arm of the bay is also free from obstruction after passing a dry rock at the mouth. From this point to the head of the harbor the passage is open. Vessels will find good anchorage in depths ranging from 7 to 16 fathoms. At the entrance head of the harbor there is an

abundance of wood and several small streams carrying a supply of water for steamers or sailing vessels. From the ship, with hand lines, 1 halibut, weighing 85 pounds, and 15 cod were caught; also 1 halibut, weighing 85 pounds, on a trawl set at the mouth of the bay, in 15 fathoms; rocky bottom.

July 27, the storm having abated, the *Albatross* steamed out of the bay and headed offshore, and at 3.15 p. m. made a set in 49 fathoms, rocky bottom, 7 miles from East Chugach Island, which bore W. $\frac{3}{4}$ S., in which position 15 halibut, averaging 12$\frac{3}{4}$ pounds and 30$\frac{1}{4}$ inches, and 9 cod were taken, a convincing indication that the ground here is prolific. It is also safe to say that along the coast from Port Dick to the westward beyond the Chugach Islands, also offshore in depths ranging from 40 to 50 fathoms, halibut are to be found in paying quantities.

At 7 p. m. a position was occupied in 66 fathoms of water, rocky bottom, Pearl Island bearing NW., distance 6 miles, or latitude 59° 00′ 00″ N., longitude 151° 34′ 00″ W. Owing to the strong tide which was running, which did not show its full strength until the anchor of the trawl reached bottom, the ground line parted, causing the loss of a large portion of the trawl. On the few remaining hooks 2 halibut were taken, weighing 10 and 16 pounds, respectively.

It may be suggested that in order to make successful sets on this ground, where the tide enters and flows out of Cook Inlet with considerable force, two dories should be used, one at each end of the trawl. By this method there would be less danger of losing the gear should it part, which is likely to be the case on rocky bottom, particularly when a strong tide runs, such as found here at most times, as the second dory would, in the majority of cases, secure the remaining portion of the trawl. Undoubtedly there is a large quantity of halibut in this region, and probably adjacent grounds are equally good. The chief objection to this ground is the probability of losing a large amount of gear. Means of overcoming the danger of such loss would no doubt be found, however, once it became known to fishermen that halibut were plentiful.

A fleet of vessels carrying 10 or 12 dories each, and each dory operating 8 to 10 skates of gear, would in a very short time locate the most prolific spots, as was done by fishermen on the various grounds in southeast Alaska, Queen Charlotte ground, and off Cape Scott, Vancouver Island.

Portlock Bank.—On July 28 three trials were made on Portlock Bank, the position and depths as follows: Latitude 58° 36′ 00″ N., longitude 150° 56′ 30″ W., 43 fathoms; latitude 58° 28′ 00′ N., longitude 150° 25′ 00″ W., 36 fathoms and latitude 58° 18′ 00″ N., longitude 149° 46′ 00″ W., 42 fathoms. The trials were 17 and 22

miles apart in an easterly direction from the position of the first dory. The character of the bottom at each station was rocky.

In the first position only 4 halibut and 5 cod were taken. Attached to the hooks were many sea anemones and a hermit crab. On the ground line and snoods was a considerable quantity of what is called by fishermen "slime," and is claimed by them to be wherever found an indication of good halibut ground. The practical fishermen on board, and also Capt. H. B. Joyce, feel certain that large quantities of halibut are to be found on this ground at some season of the year, basing their opinion upon comparisons with grounds in southeast Alaska, where similar conditions exist and where halibut are abundant at certain periods and very scarce at others.

At the second station occupied the catch consisted of 8 cod. On account of the sharp rocks, of which the bottom was chiefly composed, the ground line chafed off, causing the loss of one-half the trawl and an anchor. The character of the bottom here is such as to attract halibut, the portion of the trawl saved bringing up large numbers of holothurians, ascidians, sea pens, and live shells. The result of the last trial was 6 halibut, 17 cod, and 2 red rockfish. The average weight of the halibut was $16\frac{1}{3}$ pounds and of the rockfish $15\frac{1}{2}$ pounds.

A test of the ground was made the following morning, July 29, in 69 fathoms of water, on sharp rocky bottom, latitude 58° 32′ 00″ N., longitude 148° 59′ 00″ W. A strong southeast wind was blowing, accompanied by a choppy sea and foggy at intervals. At the expiration of one hour the work of hauling the trawl began. As soon as the anchor was broken out and a strain brought to bear on the ground line, it parted, two hooks from the end. By the time the dory reached the ship the wind had increased considerably. A course was then shaped for Montague Island, situated at the mouth of Prince William Sound, off which we arrived the same evening, a distance of 80 miles from the last station occupied. The weather being very thick, the ship lay to during the night.

Mouth of Prince William Sound.—July 30 the *Albatross* came to anchor in 28 fathoms, and at 7.30 a. m. a set was made close to the ship, Cape Clear bearing N. $\frac{1}{4}$ W., distance 3 miles; bottom rocky. The trawl was set on the last of the ebb tide and hauled at the beginning of the slack tide, but before finishing the tide began to run a strong flood, making it very difficult to get the gear. The catch was 5 halibut and 7 rockfish. One halibut weighing 36 pounds was taken on a hand line from the ship; two others were brought to the water's edge but escaped. The rockfish averaged 16 pounds and the halibut 37 pounds, 45 inches long, and they were of excellent quality. In this locality success depends largely upon choosing the condition of the tide, which sweeps in and out of Prince William Sound with

considerable velocity. Later in the day very satisfactory results were obtained $3\frac{3}{4}$ miles off Danger Island, which bore N. $\frac{3}{4}$ W., depth 41 fathoms; character of the bottom, blue clay. The halibut were not saved, as the ship was well supplied with fish. Their average weight was estimated to be 10 pounds. This ground showed possibilities of supplying a large demand for halibut, 13 being taken on a single trawl which was set 1 hour and 20 minutes.

MacLeod Harbor.—In the evening the ship anchored in MacLeod Harbor, Montague Island. Shortly after coming to anchor a trawl was baited and set at the mouth of the harbor in 20 fathoms, increasing to 24 fathoms at the outer end. The bottom was found rocky in most places. A set of 12 hours resulted in 10 halibut, averaging 30 pounds, the largest weighing 85 pounds; 6 skates, 1 large ground shark, and 4 dogfish. That sharks had eaten some of the fish was indicated by the head of one halibut hanging to the hook, and this is frequently the case on ground where sharks are more or less abundant. On the grounds of southeast Alaska, and also on Flattery Bank, some 15 years ago, before extensive fishing for halibut had been carried on, it was not uncommon for fully one-third of the catch to be mutilated by ground sharks.

Should commercial fishing be extensively carried on in this locality, which is likely to be the case, vessels may find shelter in MacLeod Harbor and also Hanning Bay, $5\frac{1}{2}$ miles farther north. At MacLeod Harbor there are also good sites for buildings and wharves, and headquarters could easily be established for carrying on a fishery. A good water supply is close by, a stream emptying into the head of the harbor, and there is a cascade about one-half mile to the eastward not far from the beach. The beach extends nearly around the harbor. A dory load of salmon was taken from the stream with two hauls of a small seine, a portion being used by the ship's company and the rest for bait.

On the morning of August 1 the ship got under way at an early hour and proceeded to sea, but finding thick weather outside the sound it was considered advisable to make investigations farther north in parts of Prince William Sound, as to which favorable reports had been received of the presence of halibut.

The ship steamed through Montague Strait a distance of some 40 miles, and at noon set one trawl in 48 fathoms of water off the south side of Little Smith Island, which bore NW. $\frac{1}{8}$ W. $1\frac{1}{2}$ miles distant, the east end of Smith Island bearing NE. by N. $\frac{1}{2}$ N. $3\frac{1}{4}$ miles. Reports had been circulated that a considerable quantity of halibut had been captured in this particular locality, but the result of our investigation was negative, two turbot being caught on a trawl baited with fresh salmon. The character of the bottom was found to be muddy.

In the early part of the evening an anchorage was made in Zaikof Bay, situated on the northern end of Montague Sound. A test of the ground was made on the south side of the bay in 39 fathoms of water, rocky bottom. The trawl was baited with fresh salmon and remained set 16 hours, at the end of which time 5 halibut averaging 40 pounds, 9 skates, 3 sharks, and 1 cod were captured. One individual weighed 140 pounds, which is considerably greater than the average size of halibut on this coast. Attached to one hook was the head of a halibut, and here, as at MacLeod Harbor, it is very probable that a number of halibut had been eaten by sharks. The bottom in this bay, or at least that portion of it covered by the trawl, was composed of small rocks, pebbles, and gravel; the marine growth brought up on some of the hooks consisted of ascidians and specimens of pennatula, either one of which forms of life, wherever found on fishing grounds, implies that bottom fish, such as cod and halibut, may be expected in more or less abundance.

This trial demonstrated excellent possibilities and that a large body of halibut inhabit this section of the island. It is quite evident that a small fleet of halibut fishermen in a short time would locate the best grounds in this vicinity and soon learn to take advantage of the local conditions in these waters.

Zaikof Harbor is well sheltered from northwest and east winds, but somewhat exposed to north and northeast winds. Port Etches on the mainland, 12 miles distant, is said to be a good harbor and well protected from easterly gales.

It is very probable that herring, in their season, may be obtained for bait purposes in various parts of Prince William Sound. Salmon fishermen at Orca have stated that while in search of salmon they have frequently encountered large bodies of herring off Smith Island, Peak Island, and in Herring Bay, Knight Island. Bait being a very important factor in the halibut fishery, it is necessary to have the base of supply as near the fishing ground as possible.

Cape Hinchinbrook.—From Zaikof Harbor a course was shaped which took us across Hinchinbrook Entrance, thence eastward 8½ miles, where a trial was made in 33 fathoms on muddy bottom, Cape Hinchinbrook bearing SW. by W., and Hook Point N. ⅛ E., 6 miles. The species captured were such as might be expected on soft muddy bottom. This trial was made while waiting for the fog to clear before going offshore. Several whales were present; also a few gulls.

It may be stated that from the western end of Hinchinbrook Island to Kayak Island and a distance of 10 miles from the coast the bottom is a deposit of soft mud discharged from the Copper River. On this ground there is an absence of commercial fishes or sessile marine growth.

Between Cape Hinchinbrook and Wessels Reef.—The *Albatross* steamed offshore 19 miles from the position of the last station and anchored in 38 fathoms; bottom, mud, pebbles, and small rocks; latitude 59° 56′ 20″ N., longitude 146° 28′ 30″ W.

At 6 p. m. a trawl baited with fresh salmon was set close to the ship and remained down 1 hour and 25 minutes, capturing one small halibut. Attached to the hook were many live shells, ascidians, and small stones, an indication of a good fishing ground which no doubt attracts halibut at some portion of the year.

On August 3 trial was made in 49 fathoms, a short distance from the position of the previous set. The ground seemed to be barren, nothing being caught. A considerable quantity of soft mud was attached to the anchors, and in many places the ground line, buoy line, and snoods of the trawl were covered with it. As this kind of bottom covers a considerable area no economic species could be expected at any season on this ground.

Middleton Island.—Another trial was made at 2.30 p. m. in 25 fathoms of water 6 miles from the south end of Middleton Island, which bore E. by S. ½ S.; bottom composed of broken shells. In this position, as at the last station, there was an absence of fish of commercial species.

At the time the trawl was being set a strong southwest breeze was blowing, accompanied by a rough sea, and in consequence it was hauled after being down 45 minutes. A number of whales were seen. During the afternoon and night the ship steamed to the westward a distance of 49 miles, and at 9.40 a. m., August 4, in latitude 59° 18′ 00″ N., longitude 148° 03′ 00″ W., a trawl was set in 70 fathoms on rocky bottom. A strong southwest wind caused a sharp choppy sea. The result of this trial of 1 hour and 15 minutes was 14 cod. During the trial a salmon was observed jumping close to the ship. Our position at the time was 29½ miles from the nearest land, which was the southern end of Montague Island, situated at the mouth of Prince William Sound, into which a large body of salmon enters each season.

From this position a run of 19 miles was made to the westward, and the ground for halibut tested in latitude 59° 13′ 20″ N., longitude 148° 38′ 30″ W.; depth, 67 fathoms; character of bottom, a mixture of pebbles and mud, which is the general character of the ground within a radius of 15 miles. Judging from the bottom and the taking of two halibut in a short time, it is thought that halibut may be found here in commercial quantities before and after the salmon run in Prince William Sound is over, this opinion being based on the fact that in the waters of southeast Alaska and British Columbia halibut follow salmon to the mouth of rivers and into bays. At such times it is not unusual for halibut to leave shore grounds and follow the salmon or herring.

During the night the *Albatross* ran $68\frac{1}{2}$ miles to the eastward and on August 5, early in the morning, slowly approached the southern end of Middleton Island; weather foggy. At 8.30, the fog having cleared sufficiently to take bearings, a halibut trawl was set in 50 fathoms, the southwest end of the island bearing N. by W., $4\frac{3}{4}$ miles distant; bottom composed of rocks and shells. The trial occupied one hour, in which time four halibut were captured, their weights being 8, 23, 24, and 33 pounds. Their stomachs were comparatively empty, which was the case with a large number of stomachs previously opened. Several whales were on the ground, and on the east side of the island orcas were playing about in large numbers, sometimes as many as 40 and 50 in a school, and acting as if pursuing surface fish.

At 1.40 p. m. another trial was made on the east side of the island, the north end bearing W. $\frac{3}{4}$ S., 8 miles distant; depth, 84 fathoms.

The bottom here proved to be muddy. In a trial lasting one hour one black cod was caught. The bait on the rest of the hooks was unmolested.

On the eastern side of Middleton Island and, for that matter, all around it, the bottom which would attract halibut, cod, or other fish of the commercial species, lies near the shore.

Sunken shoals and rocks fringe the entire length of Middleton Island on the west side and extend 2 miles from the south end and some 6 miles off the north end, making navigation extremely dangerous, especially as there is no light or harbor on the island and no buoys to mark the shoals. Wesslers Reef, which lies 16 miles north, should also be given a wide berth.

There seems to be very little in this locality to warrant either cod or halibut vessels in taking the risks of prosecuting their fishery in the vicinity of the rocks and shoals around Middleton Island.

Middleton Island and Cape St. Elias, Kayak Island.—The ship ran 25 miles on a N. by E. $\frac{1}{4}$ E. course and at 6.30 (Aug. 5) a trawl was set in 65 fathoms, latitude 59° 44′ 00″ N., longitude 145° 24′ 00″ W. The specimen of bottom brought up on the lead was black mud, but on the chance of there being rocky or sandy patches near, a set was made. Here, as at the previous station, near Middleton Island, the catch consisted of one black cod. In the immediate vicinity of this position several places marked on the chart indicate bottom where cod and halibut might at times be found, one 3 miles north and another 9 miles to the westward; but for the most part the ground lying between Cape Hinchinbrook, Kayak, and Middleton Islands offers little or no inducement to fishermen, being inhabited chiefly by sharks and other bottom scavengers.

Cape St. Elias.—This cape is situated on the southern end of Kayak Island. The island is 17 miles long by $1\frac{1}{2}$ miles wide and

extends in a northerly direction, the north end being separated from the mainland by a channel 1 mile wide, the water on the north side of the channel washing Okalee Spit, which marks the southern and eastern boundary of Controller Bay.

At 6 p. m., on August 6, a position was occupied in 60 fathoms of water, muddy bottom, Cape St. Elias bearing WSW., 25 miles distant, and Cape Suckling NW. by W. ¼ W., 14 miles. At this station very satisfactory results were obtained, 5 halibut being caught in a trial lasting 1 hour and 30 minutes. The halibut were the largest yet taken during the investigation, averaging 100 pounds in weight and 53 inches in length.

Inasmuch as scattering halibut were found in this vicinity and the trial was made on muddy bottom, the result points to prolific ground close by, a probability confirmed by the quality and size of the fish.

The next trial in this vicinity was made 3 miles from Cape Suckling, which bore NW.; depth, 24 fathoms; character of the bottom, glacial mud. Two halibut and one skate were captured in this berth, the halibut weighing 8 pounds each.

Only scattering halibut might be expected on ground of this kind, but they are very good indication that there is a body of fish in the near vicinity. South of Cape Suckling some 20 miles the depth of water ranges from 180 to 225 fathoms, the bottom being composed of gray ooze; the bottom inside of the 100-fathom curve is made up largely of mud and silt, except in a few places 12 to 15 miles eastward of Cape St. Elias.

Icy Bay.—A distance of 28 miles in an E. ⅛ N. direction from our last position a sounding was taken in 90 fathoms. Finding soft, muddy bottom we continued 2 miles farther on the same course and got 100 fathoms of water. All the soundings on the chart in this particular locality being marked mud and ooze, and it being considered therefore useless to make further investigation, the *Albatross* steamed 32 miles inshore and in the evening came to anchor in 29 fathoms of water, the western entrance of Icy Bay bearing NE. ¼ E., 10 miles distant, and 6 miles directly offshore. At 8.40 p. m. a trawl was set close to the ship and remained down over night, catching 2 cod and 1 skate. No great catch of desirable fish was expected in the immediate vicinity of the ship, but it was thought that a portion of the trawl might fall on patches of hard bottom.

Icy Bay to Point Manby.—The following day, August 7, the ship got under way at an early hour, and during the day gradually worked to the eastward along the coast over soft, muddy bottom, soundings being taken frequently. In the evening, at anchor off Point Manby, trawls were set in 21 fathoms of water, on hard sand and gravelly bottom, the only suitable place found during the day. A set lasting 1

hour and 45 minutes resulted in the capture of 5 halibut averaging 30 pounds, excellent in quality and uniform in size. One halibut was caught on a hand-line from the ship. The stomach of one contained the head of a partly-digested turbot; the other stomachs were empty.

Among fishermen the uniform size of halibut taken is regarded as favorable indication that a large body of fish is near. The fishermen on board were of this opinion, and the ground in this locality affords a good opportunity to put their theory to a test.

Early in the morning of August 8 the *Albatross* steamed offshore 2 miles, making frequent soundings and getting hard bottom. At 8.20 a. m. the anchor was dropped in 10 fathoms of water on the southern edge of a shoal spot 5¼ miles SE. by E. ½ E. from Point Manby. The shoal is 3¼ miles long by ½ mile wide, extending east and west. Situated between this shoal and Ocean Cape, which marks the southern entrance to Yakutat Bay, are several other shoals on which the water is less than 8 fathoms deep, the general character of the bottom being small rocks and pebbles.

A short trial on this spot of ground, near where the ship was anchored, resulted in 3 halibut, which averaged 67 pounds, and 4 dogfish. The largest halibut weighed 100 pounds. In the wake of the dory setting the trawl, salmon were jumping. Presumably, had the trawl remained set several hours on this ground, a much greater number of halibut would have been taken. When fishermen first began to search for halibut banks off Cape Scott, in Hecate Strait, Dixon Entrance, and other localities, it frequently happened that only a few halibut were captured in the first few trials on ground which subsequently proved to be very prolific.

Malaspina Glacier.—From this anchorage the ship steamed 8½ miles in an easterly direction along the front of Malaspina Glacier, and at 11.03 a. m., on account of a dense fog, anchored 1¼ miles from the shore in 14 fathoms of water, just outside of the 10-fathom curve, sandy bottom. While waiting for the fog to clear a halibut trawl was baited and set near the ship, capturing 1 dogfish and 1 sculpin. The fog clearing revealed that we were anchored close to a glacial stream flowing through the moraine carrying a considerable quantity of mud, which discolored the water and was no doubt the cause of the scarcity of fish in this locality. There being no place of prominence along the front of the glacier by which to locate our position, bearings were taken on Ocean Cape, which bore E. ½ N., 10 miles distant. In the afternoon the *Albatross* anchored off Yakutat village.

Disenchantment Bay.—The following morning, August 9, we steamed into Disenchantment Bay at slow speed. At the time there was considerable floating ice, which, combined with fog, made it

necessary to feel our way. Entering the bay as far as the ice would permit, the ship lay to and a halibut trawl was set close to Point Latouche parallel to the shore, one end of the trawl being in 30 fathoms and the other in 60 fathoms of water, bottom hard sand. Less than one-half mile from the shore the depth was 163 fathoms. The trawl remained down 1 hour and 30 minutes and captured 2 halibut and 7 dogfish. The halibut weighed 42 and 55 pounds, respectively, and were 42 and 47 inches in length.

Several Indians, engaged in hunting hair seals, came alongside, and they informed us that they caught halibut in all parts of the bay where the water was not too deep. The water varies greatly in depth, as was indicated by the sounding taken from the ship and also by the trawl line, the ends of which were about the same distance from the shore, but in depths with a difference of 30 fathoms. Fishing in this bay would have to be confined chiefly to localities near the shore. At times, moreover, it would be difficult to fish with trawls in this part of the bay on account of the large masses of floating ice, which break off from the face of Hubbard Glacier and are scattered by wind and current over the fishing ground. In the lower part of the bay and in all parts of Yakutat Bay it is said to be possible to fish at all seasons, weather permitting. In the evening the *Albatross* anchored off Yakutat village.

Yakutat.—The Indians of Yakutat have always done more or less fishing for halibut in Disenchantment and Yakutat Bays, where suitable depths and the right character of bottom are found; also on "spots" near Ocean Cape.

It is said that there are many "spots" of good halibut ground in this vicinity, which Indians locate by landmarks. Regular halibut fishermen would meet with little difficulty in locating the best ground, as a single dory would cover a much larger area than the entire number of canoes usually engaged in fishing. Indians ordinarily fish with a single wooden hook on well-known grounds which have always supplied their wants, and in consequence they have never considered it necessary to extend their knowledge regarding the abundance or scarcity of halibut beyond local "spots." A small fleet of halibut fishermen would soon discover the grounds known to the Indians and locate the best grounds lying between Ocean Cape and Icy Bay.

At the time of the salmon run halibut are frequently caught in Yakutat Harbor. This season it was reported that several, weighing 200 pounds each, were caught by cannery men from the cannery wharf, attracted by the offal from the salmon cannery. The taking of halibut in a harbor is no criterion that they are to be found in quantities on grounds near by; those captured in the manner described are generally stragglers.

Halibut are frequently caught around the islands near Sitka, yet fishermen who have investigated outlying grounds in that locality have always met with poor success.

Prior to 1904 a considerable body of herring annually visited Yakutat, their principal ground being in a lagoon just back of the village. Since that time few herring have appeared, and the fishery has become a total failure. The disappearance of the fish is attributed to the pollution of the ground in the lagoon where most of them were caught and dressed, no care being taken to keep the water free from offal.

Vessels fishing on grounds in this region would usually find it necessary to take with them a large amount of bait. In the spring, however, when herring strike along the coast from the Strait of Juan de Fuca to Yakutat, halibut fishermen could at times obtain herring for bait purposes at other places adjacent to Yakutat.

Ocean Cape and Icy Bay.—It is thought that the grounds within the above-mentioned limits have a sufficient commercial value to warrant one or two halibut steamers making extensive trials at a time when halibut are scarce in the vicinity of Cape Spencer, the most northern region in Pacific waters where the halibut fishery has been conducted. It frequently happens during the summer months that considerable cruising is done by the steamers in search of fish, and should a small portion of the fleet repair to this ground it is not unreasonable to suppose that fairly good results would attend the trials made. This area seems as much worthy of consideration as a number of small banks farther south, where extensive fishing has been carried on during the last 10 or 12 years and where, though at first few halibut were found, the grounds subsequently proved to be valuable.

South of Yakutat Bay.—On the morning of August 10 we left Yakutat and steamed down the coast from Ocean Cape 28 miles on a SE. by S. ¼ S. course and sounded, expecting to find rocky bottom, as indicated on the chart. Finding muddy bottom, six soundings were taken at intervals of 2 miles. At the last sounding, latitude 58° 53′ 00″ N., longitude 139° 47′ 00″ W., depth 85 fathoms, finding bottom less muddy than at the previous soundings and mixed with sand, a test of the ground was made. The trial lasted one hour, resulting in a catch of one dogfish. This position was 39 miles from Dry Bay.

For a distance of 90 miles south of Ocean Cape the character of the bottom, or at least that portion of it sounded over by the *Albatross*, is such as to preclude the possibility of its being a halibut ground. This is confirmed by the chart. There may be scattering patches of bottom where halibut exist, but it is doubtful whether in large quan-

tities. After this set the ship steamed at slow speed all night on a S. $\frac{3}{4}$ E. course, covering $49\frac{1}{2}$ miles.

On the following day, August 11, at 4.45 a. m., investigated the ground in 70 fathoms, rocky and sandy bottom, Lituya Bay 38 miles distant and bearing N. by E. $\frac{1}{2}$ E. An hour was given to the trial; and 7 halibut, 1 rockfish, and 1 cod constituted the catch. Only one of the halibut was brought on board. It weighed 115 pounds, and the others were estimated to range from 20 to 50 pounds in weight. The stomach of the individual brought on board contained a rockfish. On one of the trawl hooks was a piece of sponge and an ascidian.

A station was occupied $8\frac{1}{2}$ miles NE. $\frac{1}{2}$ E. from where the last set was made, in 53 fathoms, Lituya Bay bearing NE. $\frac{1}{2}$ N., 32 miles, the bottom composed of sand and pebbles. The catch was 2 halibut and 4 rockfish. The halibut were small, estimated 10 and 15 pounds. It is quite evident that halibut were quite numerous in this particular locality, as each of the individuals captured was "jigged," and the fish evidently did not care for salt bait, which was the only kind the *Albatross* carried.

Another indication that this is a good ground for halibut was the richness of the bottom, the hooks bringing up large quantities of pennatulids and sea anemones.

A few salmon were jumping near the ship and several whales were on the ground. The banks lie from 15 to 25 miles offshore from the Fairweather Range, have suitable depths of water, and cover a large area; and it is thought that should halibut fishermen carefully investigate the ground in this latitude they would be well rewarded.

Our next trial was $2\frac{3}{4}$ miles from Harbor Point, Lituya Bay, situated on the south side of the bay, bearing NE. $\frac{1}{2}$ N. In a depth of 40 fathoms, on bottom composed of sand and gravel, a trial of one hour resulted in 6 halibut, 4 skates, and 2 dogfish. The halibut were estimated to weigh about 10 pounds each. It is evident that at this season there are few fish on the inshore grounds. The bottom is also less attractive than it is offshore, very little marine growth being taken on the trawl.

The last trial in this region was made on the morning of August 12 in 77 fathoms of water $8\frac{1}{2}$ miles S. $\frac{3}{4}$ W. from Cape Cross, Yacobi Island. The bottom being rocky, it was difficult to haul the trawl, and 2 halibut, their combined weight 54 pounds, 10 rockfish, and 8 dogfish was the catch. At the proper season halibut are likely to be found in more paying quantities. As this ground no doubt has frequently been visited by vessels fishing in the vicinity of Cross Sound, it is probable that the banks and "spots" within a radius of 25 miles or more are well known to fishermen.

In the evening of August 12 the *Albatross* arrived at Sitka and preparations were made for coaling ship. Scattering halibut are caught near Sitka at all seasons, but no banks of commercial importance have been reported or found in the near vicinity. Indians usually catch all that they require for home consumption among the islands of Sitka Bay, but the amount is not large.

In the evening of August 20 we left Sitka and the following morning began a line of soundings off Coronation Island, toward Forester Island, for the purpose of ascertaining the depth of water and character of the bottom, where it had been reported that the water was comparatively shallow, and also to mark the outer margin of fishing banks in this region.

The first sounding was in latitude 55° 57′ 30″ N., longitude 135° 27′ 00″ W. In this position no bottom was found at 250 fathoms, and the vesesl steamed 5 miles in an E. by S. $\frac{3}{4}$ S. direction and sounded in 134 fathoms. Four other soundings were taken on this line 3 miles apart, the depths varying from 103 to 110 fathoms. After this soundings were taken 6, 10, 14, and 11 miles apart, covering a distance of 41 miles, and in depths of 116, 138, 110, and 116 fathoms. The general character of the bottom was hard sand. From 4 to 6 miles farther offshore it drops off into profound depths, 400 and 600 fathoms. We were on the western edge of the bank. Between this ridge and Baranof Island and the outlying islands is assumed to be good halibut ground. The depths range from 50 to 85 fathoms.

No attempt was made to make a practical test of ground covered by the line of soundings, the depths of water and general character of the bottom being considered sufficient knowledge concerning this region, lying as it does in close proximity to the banks, where fishing is extensively carried on. Fishermen in possession of the above information will have no difficulty in determining for themselves the value of the ground.

Coronation Island ground.—One of the first localities investigated between Dixon Entrance and Sitka Bay was around Coronation Island, where in several places known to fishermen large catches have been taken in the last two years. A considerable body of fish has also been located about 40 miles south of Cape Ommaney, situated on the southern end of Baranof Island at the entrance of Christian Sound. Fishermen have made little or no attempt to locate fishing grounds offshore from Coronation Island. A location is generally exhausted, or at least greatly depleted of fish, before the possibility of new banks in the same region is seriously considered.

It is only when fish are scarce on the inshore grounds that attempts have been made to find new places, and it was in this way that the

grounds mentioned were discovered, Forester Island being one where a portion of the fleet has met with success in the last two years.

Soundings off the west coast of Queen Charlotte Islands.—On the morning of August 22 we sounded in 1,368 fathoms of water, 60 miles from the previous sounding taken, 38 miles SSW. ¼ W. from the Kerourat Islands, latitude 51° 29′ 00″ N., longitude 131° 48′ 00″ W. The Kerourat Islands extend offshore from Cape St. James, the southern end of the Queen Charlotte Islands.

In the position of this sounding fishermen had reported shoal water. The chart soundings in this locality ranged from 800 to 1,500 fathoms and, with the sounding taken by the *Albatross*, preclude the possibility of there being shoal water in this region.

Shoal water is confined near the west coast of the Queen Charlotte Islands, and halibut have been found there, but in no great quantities any considerable distance from the shore. It is reported that the west side of the island offers little inducement to halibut fishermen. Many vessels have made an investigation of the inshore grounds, but with little or no success.

From the foregoing it is to be assumed that no fishing banks of importance exist off the coast of the Queen Charlotte Islands south from Dixon Entrance to the latitude of the Cape Scott ground, a distance of over 200 miles. From Dixon Entrance northward, however, farther offshore than has been found necessary to fish, vessels will find suitable ground. It was not possible for the *Albatross* to make an extensive survey of these grounds in one season. By noting the positions given and referring to the accompanying charts it will be found that enough information is available to render it comparatively easy for fishermen to develop the banks.

Cape Scott ground.—On the morning of August 24 several trials were made in the vicinity of Cape Scott, the first in 52 fathoms on rocky bottom, the south end of Cox Island bearing NW. ¾ N., 3¾ miles distant. At the expiration of one hour the trawl was hauled and 3 halibut were taken, their average weight 82 pounds. The largest taken weighed 150 pounds. One small ratfish was also caught.

Very little fishing for halibut has been done off the south side of Cox, Triangle, and Haycock Islands, it being stated that halibut have never been found in such numbers as to warrant a second trial. It also has been said that halibut have never been taken directly south of these islands and Scott Channel. Such, however, seems not to be the case, as scattering individuals have been taken on this ground by the fishermen on board in the last two years.

A trial off the north end of Scott Channel in 28 fathoms of water, the east end of Cox Island bearing SW. by W. ⅛ W., 5½ miles, resulted in 2 averge-sized halibut. This is a favorite "spot" for

halibut, and in the spring and early summer a considerable fleet of vessels resort to it, catching large fares. No fishing vessels of any description were on the bank at the time, and neither had we observed any off the coast of Baranof and Prince of Wales Islands. It was subsequently learned that many vessels of the fleet had suspended operations for a time, owing to the scarcity of bait.

The bank has an area of about 850 square miles and extends from Cape Scott, Vancouver Island, westward along the northern side of Cox, Lanz, Haycock, and Triangle Islands, in places from 5 to 12 miles offshore in a northerly direction and some 15 miles in a northwesterly direction beyond Triangle Island, the most western island of the group. Fishermen assert that in proportion to its size this bank has furnished as many if not more fish than any other bank off the Pacific coast. In recent years, however, owing to the extensive fishing which had been carried on, there has been an appreciable decrease in the supply. This, like all halibut grounds which have been overfished, requires "rest," and it is very probable that in a few years, should a portion of the fleet seek more northern and western waters, which is likely to be the case, the bank will be restocked by natural process. Several banks of the Atlantic which had become nearly depleted of halibut through excessive fishing and abandoned for a number of years, were found on return to them to be quite as prolific as formerly, though they in course of time relapsed into their previous condition.

In the early history of the halibut fishery on the Pacific coast, the grounds lying off Cape Scott, on the northern end of Vancouver Island, were among the first resorted to, the fishermen having been told of these grounds by the Indians living at Fort Rupert, a small village situated on the east side of the island and not far from Cape Scott. At that time few vessels were engaged in the industry, and they confined their operations to inshore grounds, not finding it necessary to investigate small patches farther out. In consequence, the fishermen possessed no positive knowledge of the extent of the bank and when the spots of ground known to them became exhausted it was naturally supposed that no others existed on that part of the coast. This was in 1895. As the fishery increased in importance larger vessels were employed and several steamers were introduced, doing more or less cruising and making practical tests on grounds not previously fished, with the result of doubling the previous size of the Cape Scott ground and for a number of years yielding exceptionally large fares.

This condition also prevailed in the vicinity of Dixon Entrance and farther north on the west coast of Prince of Wales Island, where it was thought that a small fleet, by constant fishing, would soon tem-

porarily exhaust the ground. It is true that in the region mentioned no large bank has been discovered between Cape Muzon and Christian Sound, but since the introduction of steamers and larger sailing vessels a much greater area has been developed, which has furnished the market with several million pounds of halibut. In the last few years, however, these prolific grounds have shown signs of temporary depletion which has caused a more diligent search farther offshore.

Icy Strait.—This strait, which comes in the same category, was first visited for halibut about 15 years ago. The fishery was started on a small scale with a cannery steamer after the salmon season had closed, and the catch was shipped to market by the regular line of steamers plying between southeast Alaska and Puget Sound ports. Several shipments were made during the winter, and as the work proved remunerative the captain of the steamer continued in the fishery the following winter. Soon several other steamers were added to the winter fleet, and also a number of small sailing vessels. As the demand for halibut increased and it became known that large numbers of the fish inhabited this and adjacent regions the fishery, instead of being conducted only in the winter months, was extended to cover all seasons when the fish were obtainable.

Fishing was wholly confined to Icy Strait and small bays and inlets among the islands bordering the strait. It is only in recent years that vessels have sought waters any considerable distance west from the mouth of the strait in the vicinity of Cape Spencer.

As stated elsewhere, this ground lies comparatively near the southern part of what might be termed the Fairweather Bank, which extends northward about 60 miles in the latitude of Dry Bay.

Sydney Inlet, Vancouver Island.—On the morning of August 25 a sounding was taken 25 miles S. ½ E. from Esteban Point, getting no bottom at 250 fathoms and demonstrating that in the immediate vicinity of this position the water is too deep for commercial fishing. Another sounding was then taken 22 miles from the light, which bore N. ¾ W. While the depth of water found was not too deep for operating halibut trawls, the character of the bottom did not indicate ground such as halibut frequent.

At 8 a. m., having got 80 fathoms and finding the bottom composed of mud and sand mixed, a skate of trawl was set, Esteban Point bearing NW. by N. ¾ N. 18 miles. A trial lasting one hour afforded 3 black cod and 1 red rockfish. Fishermen in this locality are largely guided to the best fishing grounds by landmarks. A distance of one-half mile and sometimes a less distance off the proper mark will often put them on barren ground.

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The soundings taken and the trial made in this locality were for the purpose of ascertaining the character of the bottom and depth of water on the edge of the bank offshore from the positions where fish are usually caught. Judging from the depth and character of bottom found, it would seem that fishermen have thoroughly covered the ground and already possess the necessary knowledge of this part of the coast for all practical purposes connected with the fishery.

A considerable fleet of small craft, which harbor in Sydney Inlet during stormy weather, fish on this ground and Flattery Bank in spring and continue until the scarcity of halibut makes it no longer profitable, after which they repair to more northern localities.

Flattery Bank.—Continuing southward along the coast a short set was made with 2 skates on muddy and sandy bottom in 76 fathoms 30 miles from Amphitrite Light, which bore NE. by E. $\frac{3}{4}$ E., where 1 red rockfish and 4 dogfish were caught. Notwithstanding the short time the trawls remained down, it was sufficiently long to demonstrate what sort of a catch might be expected. Earlier in the season this ground affords good fishing.

From this position the ship proceeded 2 miles on a S. by E. $\frac{1}{4}$ E. course and found 86 fathoms, muddy bottom. Ran 2 miles farther on the same course and got 92 fathoms. Close to this sounding the chart shows a depth of 225 fathoms, and a distance of 2 miles on the same line brought us into a depth of 150 fathoms, all of which indicated that we were on the outer edge of the bank.

A distance of 8 miles in an ENE. direction brought us into a depth of 60 fathoms, 32$\frac{1}{2}$ miles from Cape Beal, on the southwest end of Vancouver Island, which bore NE. Here a trawl was set which remained down one hour, taking 4 black cod, 3 rockfish, and 2 skates. As at the previous station, the bottom consisted of hard mud and sand.

Steaming back on the course 2 miles, a trawl was set in 63 fathoms, bottom hard and rocky. From this position Cape Beal bore NE., 34$\frac{1}{2}$ miles distant. In a trial which lasted one hour, 5 rockfish, 1 black cod, and 1 ground shark were caught. The trawl was found to be "hung up" on the rocks, causing the loss of an anchor and about half of the ground line. To many of the remaining hooks were attached basket starfish, an indication of good ground.

In the previous trials farther north earlier in the day there was an absence of the bottom life such as is known to attract halibut.

Flattery Bank has been resorted to for halibut since 1888, during which time it is very probable that each year a large portion of the ground within the 100-fathom curve has been fished on, and the best grounds contained within that area located by landmarks.

A bank lying so near the coast, and with several harbors within comparatively easy reach, seems to require no special investigation more than what can easily be performed by fishing vessels. Vessels setting trawls at random and making "flying sets" on various parts of the bank to test the ground in some particular locality will naturally at some time discover any "spot" of good ground not already known.

The chance of finding prolific fishing grounds beyond a depth of 100 fathoms or more is not great, although it is reported by some and supposed by others that small isolated banks exist outside of the plateau which forms Flattery Bank and adjoining ground on the north. This theory no doubt is based on reports circulated by fishermen and others who have noticed patches of discolored water, it being taken for granted that here were banks because the water had the appearance of being shallow. To prove or disprove the truthfulness of these reports would require considerable time, especially as no definite positions are given.

No further trials were made, and in the evening of August 25 we left the bank and steamed up the Straits of Juan de Fuca and proceeded to Comox, British Columbia, where the *Albatross* remained three days taking in coal.

On the morning of the 29th Capt. Joyce and the four fishermen were landed at Seattle. On the morning of September 2 the ship anchored off Sausalito, San Francisco Bay.

HALIBUT INVESTIGATIONS, FISHERIES STEAMER "ALBATROSS," SUMMER OF 1911.

Position.	Date (1911).	Depth.	Character of bottom.	Temperature. Air.	Temperature. Surf.	Number of trawls.	Time. Set.	Time. Hauled.	Bait.	Halibut taken.	Average size.	Average weight.	Remarks.
SOUTHEAST ALASKA.		Fath.		°F.	°F.						Inches.	Pounds.	
Vicinity of Killisnoo: Table Island, N. 84° E.; left tangent Killisnoo Island N. by E.	June 2	75	Rocky	46	44	2	7.30 p. m.	5.00 a. m. (June 3).	Salt herring				34 black cod, 8 rockfish, 7 turbot, 10 ground sharks.
PORTLOCK BANK.													
Eastern edge: 58° 20′ 00″ N., 150° 30′ 00″ W.	June 5	38	Hard sand, fine gravel.	44	42	2	1.53 p. m.	3.13 p. m.	Salt herring	28	29½	16	40 cod. During the trial 54 cod were taken from the ship with 4 handlines. Size 18 to 36 inches.
KODIAK ISLAND.													
Halibut Bay	June 6	15											50 cod caught in 1 hour from the ship with 4 handlines.
CHIGNIK BAY.													
Anchorage Bay, Chignik Harbor	June 9	26											25 cod and 1 small turbot caught during trial of 2 hours with 4 handlines.
Do	do	26		43	42	1	3.30 p. m.	4.30 p. m.	Salt herring				11 cod, 1 turbot, 1 sculpin.
Off mouth of Chignik Harbor	June 10	26	Sand, mud							3			23 small cod, 3 small halibut, 1 turbot; 2 handlines.
Do	June 11	28											74 cod, 1 turbot, 6 sculpins; 2 handlines.
Do	June 12	28								1	27½	8	59 cod; 2 handlines.
Do	June 18	25	Sand, rocky							17	31	17	84 cod; 2 handlines; 5 hours.
		25	do	59	46	1	9.00 a. m.	2.00 p. m.	Salt herring				
Do	do	25	do							2	26¼	11½	45 cod; 2 handlines.

VICINITY OF AKUTAN PASS.													
Off mouth of Akun Bay, Akun Island.	June 28	41–74	Fine gray sand	43	40	4	9.35 a. m.	10.55 a. m.	Salt herring	5	28	10	115 cod.
Lost Harbor, Akun Island	...do	20	Rocky	45	41	1	3.00 p. m.	4.00 p. m.	...do	2	25	6	10 cod.
Akutan Harbor, Akutan Island	...do	27	...do	45	43	1	5.15 p. m.	6.45 p. m.	...do	1	21	4	12 cod.
Off North Head, Akutan Island	June 29	26	...do	45	43	1	7.00 a. m.	8.00 a. m.	...do	1	23	5	38 cod, 3 skates, 2 sculpins.
				47	41	1	8.18 a. m.	9.18 a. m.	...do	...	...	...	12 cod, 2 turbot, 3 skates, 2 sculpins
SLIME BANK, BERING SEA.													
Cape Lapin, SE., distance 16 miles.	July 6	43	Black gravel	44	44	2	7.00 a. m.	7.40 a. m.	Salt herring	...	...	...	54 cod, 1 turbot, 1 skate, 1 crab.
Cape Sarichef, distance 22 miles, 54° 53′ 00″ N., 165° 20′ 00″ W.	...do	54	Sand, gravel	44	42	1	4.00 p. m.	4.45 p. m.	...do	...	...	...	6 cod.
DAVIDSON BANK.													
Southeast end of Tigalda Island, bearing N., distance 3 miles, 53° 45′ 00″ N., 164° 30′ 00″ W.	July 7	42	Gray sand	42	42	1	7.00 a. m.	7.40 a. m.	Salt herring	...	...	...	11 cod, 1 flounder, 1 sculpin.
	...do	62	Fine gray sand	44	44	1	12.45 p. m.	1.45 p. m.	...do	...	...	...	12 cod.
SANNAK BANK.													
Seal Rock, bearing W. by N. ½ N., 54° 13′ 00″ N., 162° 10′ 00″ W.	July 8	50	Pebbles, rock.	43	43	1	8.00 a. m.	9.00 a. m.	Salt herring	3	30	10	28 cod, 1 red rockfish, 1 octopus.
	...do	43	...do	43	43	1	8.10 a. m.	8.40 a. m.	...do	...	...	...	63 cod, 2 octopi.
Lookout Point, Canton Island, bearing NW. ¼ N., distance 16 miles, 54° 08′ 00″ N., 162° 11′ 20″ W.	...do	64	Rocky	44	44	1	11.50 a. m.	12.50 p. m.	...do	2	26	8	
Lookout Point, Canton Island, bearing NW. ¼ N., distance 18 miles, 54° 8′ 30″ N., 162° 11′ 20″ W.	...do	45	Very rocky	44	44	1	12.10 p. m.	1.10 p. m.	Salt herring, fresh octopus.	...	...	...	In trying to get up anchor buoy line chafed off on a rock.
Pinnacle Rock, bearing NW. ½ W., distance 17 miles, 54° 31′ 00″ N., 161° 33′ 00″ W.	...do	47	Rocky	46	42	1	6.04 p. m.	7.34 p. m.	Salt herring	2	26½	7½	8 cod, 9 sculpins.
SHUMAGIN BANK.													
Mountain Cape, Nagai Island, bearing ENE., distance 16 miles, 54° 53′ 00″ N., 160° 38′ 30″ W.	July 9	40	Sand, pebbles.	50	44	1	1.00 p. m.	2.00 p. m.	Salt herring	1	20½	3	3 cod, 2 sculpins.
Mountain Cape, Nagai Island, bearing N. ½ E., distance 22 miles, 54° 34′ 00″ N., 160° 24′ 00″ W.	...do	80	Sand, gravel	49	44	1	6.05 p. m.	7 05 p. m.	...do	3	29	10	16 cod, 1 turbot.
Simeonof Island, bearing WSW., distance 21 miles, 54° 55′ 00″ N., 158° 34′ 00″ W.	July 10	90	Mud, sand	48	46	1	7.00 a. m.	8.20 a. m.	...do	...	...	...	4 cod, 1 skate.

HALIBUT INVESTIGATIONS, FISHERIES STEAMER "ALBATROSS," SUMMER OF 1911—Continued.

Position.	Date (1911).	Depth.	Character of bottom.	Temperature. Air.	Temperature. Surf.	Number of trawls.	Time. Set.	Time. Hauled.	Bait.	Halibut taken.	Average size.	Average weight.	Remarks.
SHUMAGIN BANK—continued.		Fath.		° F.	° F.						Inches.	Pounds.	
Simeonof Island, bearing WSW., distance 40 miles, 54° 53′ 00″ N., 157° 48′ 00″ W.	July 10	48	Rocky	54	44	1	12.30 p. m.	2.00 p. m.	Salt herring	8	34½	18	39 cod.
2 miles SSE. from position of 1st dory.	do	48	do	54	44	1	12.45 p. m.	1.05 p. m.	do	3	25	7	27 cod.
2 miles SSE. from position of 2d dory.	do	52	Gray sand	54	44	1	12.58 p. m.	2.28 p. m.	do				17 cod.
3 miles SSE. from position of 3d	do	70	Fine sand	54	44	1	1.22 p. m.	3.02 p. m.	do				14 cod.
dory 54° 59′ 30″ N., 157° 43′ 00″ W.	do	42	Gravel, rocks	56	46	1	4.57 p. m.	6 30 p. m.	Salt herring, fresh halibut.	8	33	20¼	31 cod, 7 sculpins, 1 starfish.
55° 01′ 30″ N., 157° 43′ 00″ W	do	42	do	49	46	1	5.20 p. m.	6 45 p. m.	Salt herring	6	30	11	15 cod.
OFF SEMIDI ISLANDS.													
Lighthouse Rock, bearing WNW. ¼ W., distance 7 miles.	July 11	48	Rocky	47	44	1	6.15 a. m.	7.15 a. m.	do	1	25	6	4 cod.
Lighthouse Rock, bearing W. ¼ S., distance 10 miles.	do	48	Small rocks, sand.	48	44	1	8.05 a. m.	8.35 a. m.	do	4	23	5	21 cod.
2 miles from 1st dory, NE. ¾ N.	do	49	Rocky	48	46	1	8.20 a. m.	10.00 a. m.	do	5	26½	9	10 cod.
2 miles from 2d dory, NE. ¾ N.	do	50	Small pebbles, sand.	48	46	1	8.45 a. m.	10.30 a. m.	do	7	28	9¾	12 cod.
3 miles from 3d dory, NE. ¾ N.	do	53	Small rocks	48	45	1	9.20 a. m.	11.10 a. m.	do	7	20	10	9 cod.
Chowiet Island, bearing NW. ½ W., distance 6½ miles.	do	100	Sand	48	44	1	1.15 p. m.	2.40 p. m.	Salt herring, fresh cod.				26 cod, 2 skates, 1 basket starfish.
CHIRIKOF ISLAND.													
North end Chirikof Island, bearing E., distance 11 miles.	July 11	40	Dead shells	46	45	1	6.50 p m.	8.10 p. m.	Salt herring, fresh cod.	2	28	10½	8 cod, 1 skate.
WESTERN ENTRANCE SHELIKOF STRAIT.													
Cape Ikulik, bearing N. by W., distance 6 miles.	July 12	58	Shells, rocks, black mud.	47	45	1	7.00 a. m.	8.40 a. m.	Salt herring, fresh cod	7	26	8	16 cod, 16 skates, 2 turbot.
Low Cape, bearing E. by N., distance 8 miles.	do	34	Rocky	52	48	1	12.35 p. m.	1.35 p. m.	do	13	20½	11¾	9 cod, 1 skate, 4 sculpins, 1 octopus.

1 mile from 1st dory, S. by E. ¾ E.	...do....	52	.....do........	52	48	1	12.50 p. m.	1.50 p. m.	.....do........	8	29	14	13 cod, 1 sculpin.
Cape Alitak, bearing NE. by N., distance 10 miles.	...do....	27	Shells, small pebbles.	56	49	1	4.55 p. m.	6.10 p. m.	.....do........	4	26¾	8¼	11 cod, 1 turbot, 2 skates.
2d dory, ½ mile E. by N. ½ N	...do....	40	Blue clay.....	57	49	1	5.02 p. m.	6.32 p. m.	Salt herring...	3	28	10⅓	3 skates, 1 turbot.
ALBATROSS BANK.													
56° 21′ 00″ N., 153° 15′ 00″ W.....	July 13	18	Hard, rocky...	45	46	1	4.50 a. m.	5.50 a. m.	Salt herring, fresh octopus.	....	....	....	6 cod; lost all ground line except a short piece.
56° 36′ 00″ N., 152° 56′ 00″ W	...do....	44	Sand, gravel..	49	48	1	10.15 a. m.	11.35 a. m.	Salt herring...	4	23¼	5½	28 cod, 1 skate, 1 sculpin.
57° 00′ 00″ N., 152° 21′ 00″ W	...do....	45	Hard rocks....	58	48	1	6.40 p. m.	8.10 p. m.	.....do........	2	30	15	17 cod, 2 skates.
PORTLOCK BANK.													
57° 31′ 00″ N., 151° 11′ 00″ W	July 14	42	Rocks, shells..	45	47	1	5.00 a. m.	6.00 a. m.	Salt herring...	2	26½	8	19 cod, 1 sculpin.
57° 46′ 00″ N., 151° 27′ 00″ W	...do....	34	Rocky........	46	44	1	10.10 a. m.	11.30 a. m.	.....do........	3	25½	6½	13 cod, 1 sculpin, 1 skate.
Cape Chiniak, bearing SW. ¾ W., distance 12 miles.	July 17	54	Rocks.........	56	48	1	12.45 p. m.	2.15 p. m.	.....do........	9	28½	9½	11 cod, 5 turbot.
Ugak Island, bearing SW. ½ S., distance 10 miles.	...do....	40	Mud, gravel, shells.	51	48	1	6.05 p. m.	7.20 p. m.	.....do........	7	24	5½	7 cod, 7 sculpin, 1 skate.
1 mile SW. by W. from 1st dory..	...do....	38	Small rocks, hard.	51	48	1	6.30 p. m.	8.10 p. m.	.....do........	3	27	8⅓	8 cod, 2 sculpin, 1 skate, 1 octopus.
57° 12′ 30″ N., 151° 12′ 00″ W.....	July 18	72	Small rocks, pebbles.	50	49	1	4.50 a. m.	6.00 a. m.	.....do........	....	....	....	9 cod, 1 black cod, 1 Attu mackerel.
57° 27′ 00″ N., 150° 40′ 00″ W.....	...do....	62	Coarse sand...	62	51	1	1.45 p. m.	3.25 p. m.	Salt herring, fresh cod.	3	38⅔	9⅓	33 cod, 1 skate.
57° 42′ 00″ N., 150° 42′ 00″ W.....	...do....	55	Sand, rocks...	56	50	1	5.50 p. m.	6.35 p. m.	.....do........	5	30	13	32 cod.
Marmot Cape, bearing W., distance, 5 miles.	July 19	55	Dead shells...	53	48	1	6.27 a. m.	7.47 a. m.	Fresh cod.....	....	....	....	2 cod, 2 skates.
Izhut Bay, Afognak Island; Pillar Cape, bearing NE. ¼ E., distance 5 miles.	...do....	30	Rocky........	63	51	1	11.10 a. m.	12.40 p. m.	Fresh cod, salt herring.	3	33	21	41 cod, 1 rockfish, 5 sculpins.
Off Narrow Strait, Afognak Island; South Point Spruce Island, bearing W. ½ S., distance 3.8 miles.	...do....	20	Sand, gravel, rocks.	50	51	1	3.00 p. m.	4.20 p. m.	Salt herring...	1	28	9	11 cod, 8 sculpins.
WESTERN EDGE PORTLOCK BANK.													
58° 06′ 30″ N., 151° 00′ 00″ W.....	July 20	65	Coarse sand...	46	48	1	5.00 a. m.	5.45 a. m.	Salt herring...	1	33	15	11 cod.
58° 03′ 00″ N., 150° 32′ 00″ W.....	...do....	50	Rocky........	48	49	1	11.55 a. m.	12.55 p. m.	.....do........	8	33	13¾	13 cod, 2 rockfish, 1 octopus.
58° 16′ 00″ N., 150° 20′ 00″ W.....	...do....	48	Rocks, pebbles	50	51	1	4.18 p. m.	5.23 p. m.	.....do........	6	32	22	14 cod, 2 skates.
1½ miles N. by W. from 1st dory..	...do....	52	Shells.........	50	51	1	4.30 p. m.	5.50 p. m.	.....do........	7	33	18	16 cod, 2 skates.
South end of Cheval Island, near beach.	July 24	50	Rocky........	58	57	1	9.45 a. m.	11.05 a. m.	.....do........	3	21	4	7 cod, 2 turbot.
South side of Seal Rocks; Aialik..	...do....	57	.....do........	68	58	1	2.35 p. m.	3.35 p. m.	.....do........	1	27	9	1 skate.
Mouth of Dick Bay...............	July 27	15	.....do........	52	50	1	9.30 a. m.	10.30 a. m.	.....do........	1	56	85	2 starfish, 15 cod caught with hand lines from ship.

HALIBUT INVESTIGATIONS, FISHERIES STEAMER "ALBATROSS," SUMMER OF 1911—Continued.

Position.	Date (1911).	Depth.	Character of bottom.	Temperature.		Number of trawls.	Time.		Bait.	Halibut taken.	Average size.	Average weight.	Remarks.
				Air.	Surf.		Set.	Hauled.					
WESTERN EDGE PORTLOCK BANK—continued.		*Fath.*		° *F.*	° *F.*						*Inches.*	*Pounds.*	
East Chugach Island, bearing W. $\frac{3}{4}$ S., distance 7 miles.	July 27	49	Rocky	51	50	1	3.15 p. m.	4.35 p. m.	Salt herring...	15	$30\frac{1}{4}$	$12\frac{3}{4}$	9 cod.
Pearl Island, bearing NW., distance 6 miles.	...do....	66	.....do........	50	50	1	7.00 p. m.	8.00 p. m.	.....do........	2	$30\frac{1}{4}$	13	Lost 6 lines of trawl.
PORTLOCK BANK.													
58° 36′ 00″ N., 150° 56′ 30″ W.....	July 28	43	Rocky	49	50	1	6.12 a. m.	6.47 a. m.	Fresh halibut.	4	$33\frac{1}{4}$	$13\frac{3}{4}$	5 cod, 1 hermit crab, 1 large and many small anemones.
58° 28′ 00″ N., 150° 25′ 00″ W.....	...do....	36	.....do........	49	48	1	11.00 a. m.	12.30 a. m.	Salt herring...	....	....	....	8 cod; lost buoy lines, half skate, and anchor.
58° 18′ 00″ N., 149° 46′ 00″ W.....	...do....	42	.....do........	49	46	1	4.20 p. m.	5.20 p. m.	.....do........	6	$31\frac{1}{3}$	$16\frac{1}{3}$	17 cod, 2 rockfish.
58° 32′ 00″ N., 148° 59′ 00″ W.....	July 29	69	Rocky, shells.	52	55	1	7.20 p. m.	8.20 p. m.	.....do........	....	....	....	Lost all but two hooks.
MOUTH OF PRINCE WILLIAM SOUND.													
Cape Clear, bearing N. $\frac{1}{4}$ W., distance 3 miles.	July 30	28	Rocky........	54	55	1	7.30 a. m.	8.45 a. m.	Salt herring...	5	43	37	7 rockfish, average 16 pounds, 2 escaped; 1 halibut, 36 pounds, 41 inches. Caught from ship with hand lines.
Danger Island, bearing N. $\frac{3}{4}$ W., distance $3\frac{3}{4}$ miles.	...do....	41	Blue clay.....	55	55	1	1.10 p. m.	2.30 p. m.	.....do........	13	....	*a* 10	Not brought in.
Mouth MacLeod Harbor, Montague Island.	...do....	20–24	Rocky........	58	53	1	4.30 p. m.	5.30 a. m. (July 31)	.....do........	10	....	30	2 largest 85.59 pounds, 6 skates, 1 dogfish, 1 ground shark; 1 halibut eaten up all but head.

Little Smith Island, bearing NW. ⅜ W., distance 1½ miles, and east end Smith Island, bearing NE. by N. ½ N., distance 3¼ miles.	Aug. 1	48	Mud	62	58	1	12.00 m.	1.20 p. m.	do.				2 turbot.
Mouth Zaikof Bay	do.	39	Rocky	63	56	1	4.15 p. m.	8.15 a. m. (Aug. 2.)	Fresh salmon	5		a 40	1 halibut 140 pounds, 9 skates, 3 sharks, 1 cod.
Cape Hinchinbrook, bearing SW. by W., distance 8½ miles.	Aug. 2	33	Mud	55	59	1	1.00 p. m.	2.20 p. m.	do.				1 ground shark, 1 turbot, 1 dogfish.
59° 56′ 20″ N., 146° 28′ 30″ W.	do.	38	Rocky	60	56	1	6.00 p. m.	7.25 p. m.	do.	1			Small.
59° 56′ 00″ N., 146° 28′ 45″ W.	Aug. 3	49	Rocky, mud	57	56	1	10.00 a. m.	11.00 a. m.	Salt herring				Nothing.
MIDDLETON ISLAND.													
South end of Middleton Island, bearing E. by S. ½ S., distance 6 miles.	Aug. 3	25	Broken shells	55	55	1	2.30 p. m.	3.15 p. m.	Salt herring				Nothing.
59° 18′ 00″ N., 148° 03′ 00″ W.	Aug. 4	70	Rocky	53	54	1	9.40 a. m.	11.05 a. m.	do.				14 cod.
59° 13′ 20″ N., 148° 38′ 30″ W.	do.	67	Rocky, mud	55	55	1	5.13 p. m.	6.38 p. m.	do.	2	34	11	
Southwest end of Middleton Island, bearing N. by W., distance 4¾ miles.	Aug. 5	50	Rocks, shells	53	54	1	8.30 a. m.	9.30 a. m.	do.	4	36	19½	
North end of Middleton Island, bearing W. ¾ S., distance 8 miles.	do.	84	Blue mud	54	56	1	1.40 p. m.	2.40 p. m.	do.				1 small cod.
59° 44′ 00″ N., 145° 24′ 00″ W.	do.	65	Black mud	55	55	1	6.30 p. m.	7.50 p. m.	do.				1 black cod.
CAPE ST. ELIAS.													
Cape St. Elias, bearing WSW., distance 25 miles, and Cape Suckling, bearing NW. by W. ¼ W., distance 14 miles.	Aug. 6	60	Blue mud	55	56	1	6.00 a. m.	7.30 a. m.	Salt herring	5	53	100	
Cape Suckling, bearing NW., distance 3 miles.	do.	24	Glacial mud	56	56	1	9.12 a. m.	9.57 a. m.	do.	2		8	1 skate.
Icy Bay, bearing NE. ¼ E., distance 10 miles.	do.	29	Mud	57	57	1	8.40 p. m.	6.10 a. m. (Aug. 7.)	do.				2 cod, 1 skate, 1 shark.
Point Manby, bearing N. by W. ¾ W., distance 3½ miles.	Aug. 7	21	Hard sand, gravel.	52	48	1	6.50 p. m.	8.35 p. m.	do.	5	39	30	1 halibut caught from deck.
Point Manby, bearing NW. by W. ½ W., distance 5¼ miles.	Aug. 8	10	Rocks, pebbles.	47	47	1	8.20 a. m.	9.05 a. m.	do.	3	49	67	4 dogfish.
Ocean Cape, bearing E. ½ N., distance 10½ miles.	do.	14	Sand	54	46	1	12.00 m.	1.00 p. m.	do.				1 dogfish, 1 sculpin.
Disenchantment Bay, Point Latouche, bearing S. by E., distance 1¼ miles.	Aug. 9	30-60	Hard sand	57	56	1	12.00 m.	1.30 p. m.	do.	2	44½	48½	

a Approximate.

HALIBUT INVESTIGATIONS, FISHERIES STEAMER "ALBATROSS," SUMMER OF 1911—Continued.

Position.	Date (1911).	Depth.	Character of bottom.	Temperature. Air.	Temperature. Surf.	Number of trawls.	Time. Set.	Time. Hauled.	Bait.	Halibut taken.	Average size.	Average weight.	Remarks.
		Fath.		*° F.*	*° F.*						*Inches.*	*Pounds.*	
SOUTH OF YAKUTAT BAY.													
58° 53′ 00″ N., 139° 47′ 00″ W.	Aug. 10	85	Sand, mud	56	58	1	4.00 p. m.	5.00 p. m.	Salt herring				1 small dogfish.
Lituya Bay, bearing N. by E. ½ E., distance 38 miles.	Aug. 11	70	Rocks, sand	56	58	1	4.45 a. m.	5.45 a. m.	do	7		a 20–50	Largest halibut 115 pounds, 1 rockfish, 1 cod.
Lituya Bay, bearing NE. ½ N., distance 32 miles.	do	53	Pebbles, sand	58	58	1	8.15 a. m.	9.15 a. m.	do	2		10–15	4 red rockfish.
Harbor Point, Lituya Bay, bearing NE. ½ N., distance 2¾ miles.	do	40	Sand, gravel	62	58	1	2.05 p. m.	3.05 p. m.	do	6		10	4 skates, 2 dogfish.
Cape Cross, Yacobi Island, bearing N. ¾ E., distance 8½ miles.	Aug. 12	77	Rocky	56	56	1	5.00 a. m.	6.00 a. m.	do	2		20–34	10 redfish, 8 dogfish.
CAPE SCOTT.													
South end of Cox Island, bearing NW. ¾ N., distance 3¾ miles.	Aug. 24	52	Rocky	53	54	1	9.25 a. m.	10.25 a. m.	Salt herring	3	50	82	Largest halibut 150 pounds, 1 glamera (ratfish).
Off Sydney Inlet, Vancouver Island, Esteban Point, bearing NW. by N. ¾ N., distance 18 miles.	Aug. 25	80	Mud, sand	58	56	1	8.10 a. m.	9.10 a. m.	do				3 black cod, 1 rockfish.
FLATTERY BANK.													
Amphitrite Light, bearing NE. by E. ¾ E., distance 30 miles.	Aug. 25	76	Mud, sand	58	56	2	11.55 a. m.	1.25 p. m.	Salt herring				4 dogfish, 1 rockfish.
Cape Beal, bearing NE., distance 32½ miles.	do	60	do	58	56	1	4.55 p. m.	5.55 p. m.	do				4 black cod, 2 skates, 3 rockfish.
Cape Beal, NE., distance 34½ miles.	do	63	Rocky	58	56	1	5.15 p. m.	6.15 p. m.	do				5 rockfish, 1 black cod, 1 shark. Lost half skate gear and 1 anchor.

a Estimated.

SUMMARY.

To cover the fishing banks of Alaska thoroughly and indicate accurately the areas where halibut exist in commercial quantities would require several seasons of active work. An entire season should be devoted to systematic operations in each particular region, all parts of the banks being tested several times at suitable intervals and at different seasons to show their actual resources. In the short time which the *Albatross* had to carry on the work it was found impossible to enter upon such a plan, and the results accomplished are of value chiefly as indicating the lines which further investigations may profitably pursue.

No large catches of halibut were made in any one locality, but many of the trials led to the belief that thorough fishing would be profitable. The grounds which seemed to offer the greatest inducement to fishermen are included in the area extending from the western part of Albatross Bank to the Fairweather Ground. The eastern part of Albatross Bank and the western part of Portlock Bank warrant further investigations, and the inshore grounds are also worthy of attention, especially in the vicinity of the northern end of Kodiak Island, in and off the mouth of Prince William Sound, and between Marmot Island and the eastern entrance of Shelikof Strait. The plateau between Cape Spencer and Yakutat Bay would probably be quite as well worth exploitation as the southeast Alaska banks, where in many cases the fishermen have obtained only meager results for several years.

It is known that halibut exist in more or less abundance on banks extending north of Cross Sound and westward to Unimak Pass, but more knowledge is needed in regard to both numbers and migrations of the fish on these grounds before a fishery can prudently be undertaken so far from a home port.

The average weight of halibut caught by the *Albatross* was about 20 pounds, but individuals weighing from 100 to 150 pounds were also taken. It is not uncommon to find small halibut on all banks, and some of the banks which now yield the greatest number of large halibut formerly gave indications of having few fish of marketable size.

The question of bait supply will require further investigation. Should bait prove to be scarce in the fishing region, means will have to be devised to ship the supply to convenient places along the coast, long passages from the banks in search of it being neither feasible nor profitable.

Only vessels of the largest size now employed in the halibut fishery could operate with any degree of success or profit on banks situated from 500 to 800 miles or more from the nearest market. Small ves-

sels will be obliged to continue fishing on inshore grounds and banks adjacent to the coast, unless shipping facilities should be established at points in central Alaska, Kodiak Island, and other places farther west.

Vessels fishing the Fairweather Ground and Portlock and Albatross Banks will be at some disadvantage as to harbors, but on the western part of Portlock Bank and the northern and eastern part of Albatross Bank shelter can be found along the coast of Kodiak and other islands at no great distance from the fishing grounds. There are several harbors near the grounds lying southwest of Kodiak Island, and in the vicinity of the Shumagin Islands, but the heavy tide makes them dangerous in foggy weather. In the vicinity of Sannak Island and Unimak Pass, also, currents and tides of unknown direction frequently interfere with navigation.

At many of the stations occupied by the *Albatross* it was evident that vessels fitted for cod trawling would have little difficulty in securing their trips. Cod were particularly abundant on the eastern edge of Portlock Bank, Sannak Bank, and in the vicinity of Akun, Akutan, and Simeonof Islands. But while cod caught off shore are in better condition than those taken nearer in, and while their abundance on these grounds is known to the fishermen, little fishing has been done in these localities by the large vessels, and boats connected with the shore stations do not venture so far out. It is thought these offshore grounds could be worked with profit.

The investigation as a whole points to opportunity for development of the Pacific halibut fishery much beyond its present limits. The phenomenal catches landed in the last few years suggest no stringency of supply on grounds now fished, and this fact will doubtless delay the expansion of the fishery, but with the now large demand of the markets it is expected that some of the large steamers will at once proceed to develop the possibilities that have been revealed.

MUSSEL RESOURCES OF THE HOLSTON AND CLINCH RIVERS OF EASTERN TENNESSEE

Investigation by J. F. Boepple
Notes compiled by R. E. Coker, Ph. D.

Bureau of Fisheries Document No. 765

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Early in October, 1909, Mr. J. F. Boepple, shell expert in the employ of the United States Bureau of Fisheries at the biological station at Fairport, Iowa, entered upon a brief investigation of the mussel resources of the Holston and Clinch Rivers of eastern Tennessee. Mr. Boepple having died before his notes were compiled for publication, the information he obtained has been assembled in the present form.

HOLSTON RIVER, NEAR MORRISTOWN, TENN.

The investigations were begun by Mr. Boepple in the vicinity of Morristown, Tenn., where a pearl fishery was then in progress. One of the regular pearl seekers having been secured as a guide, a visit was made to the Holston River at Three Springs, about 14 miles distant from Morristown, where the piles of discarded shells were first examined. Despite the fact that the only object of the fishery as pursued at this place was the quest of pearls and the fishermen were ignorant of the market value of shells, it was observed that the discarded shells had a substantial commercial value for the purpose of button manufacture. Examination of the mussel beds of the river was also made, the principal shells obtained being muckets with some three-ridges and a few long niggerheads. An interesting feature of the beds at this point was the presence of numbers of very young mussels which were found to hang from other shells "by threads as fine as the filaments of a spider web." Several of them fell off as the shells were brought from the water into the boat. Some of these juvenile specimens as identified in the field were fluted shells and muckets.

Collecting in the river was pursued at various places, the result being about the same in each instance; muckets were always the principal shell taken. There were several small islands overgrown with rushes where feeding places of the muskrats were found, and

at such points many small shells were taken. It was noted by Mr. Boepple that a number of live mussels were found at these places; this was taken to mean either that the muskrats held a reserve supply or, as he considered more probable, that they were unable to open some of the specimens. Small mussels were also found on the stones in the river.

After working for two days at this point a collection of 100 pounds of shells was taken to Morristown for more careful examination with reference to commercial value.

The following description of the river is copied from Mr. Boepple's field notes:

> The Holston River is at this place quite a large stream a quarter of a mile wide, yet not deep, from 1 to 3 feet. The bottom of the stream is of gravel and rock, at places flat rock, and at some points in the shoals only rock. It was hard to get to these places with a small boat, yet my helper knew every point in the stream. The water was almost clear, yet somewhat milky, and one could see only about 4 feet deep. The banks were bluffs. On the north side one could see the Clinch Mountains in the background. There were likewise places in the river one-half to 1 mile in length where the river was narrow and deep and practically without current.

Previous to this visit a report had been received that pearls were being fished on the Holston, Clinch, and Powell Rivers and that the shells were being thrown into the river as without value. This report was fully substantiated, for wherever examination of the bottom could be made numbers of dead shells were observed that had evidently been thrown back into the river by the pearl fishers after examination for pearls; likewise large piles of shells amounting to several tons in each pile were seen in places on the main bank and on the shores of the islands. After careful examination of these heaps it was found that about 60 per cent of the discarded shells were good muckets, about 20 per cent long niggerheads, while a considerable number were three-ridges.

Some information was obtained in regard to the pearl fishery. During the three years immediately previous there had been 10 to 12 men fishing for pearls in this vicinity, often working for two or three weeks before finding anything of real value. Mr. Boepple was informed by his guide, a reliable pearl fisher, that during these three years he had found one pearl for which he received \$800, another which brought him \$410. He had also found several for which he received from \$10 to \$50 each. A number of pieces which he then had in hand were observed, all of which possessed a good luster. The principal season for pearling is during the months of July, August, and September.

Advice was given to the pearl fishers in regard to what species of the shells possessed a commercial value, and in regard to the market for such material. It was also explained that many of the shells previously discarded were not yet ruined for market purposes; so

that a good return might be obtained by sorting these out until a carload lot was obtained. It was the opinion of Mr. Boepple that although among the dead shells in the river and along the banks many were without value, yet several carloads of good shells could be found. It has been learned since that the information given by Mr. Boepple was availed of, and that a considerable quantity of good shells from this region have reached the market.

Several species of mussels were found to be "spawning" (gravid), namely, muckets, pocketbook, fluted-shells, kidney-shells, and fan-shells. The proper scientific names of these species will be found in a list given below, showing the mussels found at this place with an approximate estimate of the commercial value of the shells. Particular attention was given to a test of the value of the yellow-back and green-striped mussels, which are the principal shells of these beds.

SHELLS COLLECTED IN THE HOLSTON RIVER NEAR MORRISTOWN, TENN.

Common name.	Scientific name.	Commercial value per ton.
Yellow mucket	Lampsilis ligamentina gibba[a]	$79.80
Green-striped mucket	Lampsilis ligamentina	79.80
Large black mucket	do	12.00
Pocketbook	Lampsilis ventricosa	12.00
Fluted-shell	Symphynota costata	
Three-ridge	Quadrula undulata	10.00
White pig-toe	Quadrula obliqua	10.00
Niggerhead	Quadrula ebena	15.00
Long niggerhead	do	15.00
Hatchet-back	Lampsilis alata	
Spectacle-case	Margaritana monodonta	
Black sand-shell	Lampsilis recta	15.00
Elephant-ear	Unio crassidens	
Purple pimple-back	Quadrula granifera	
Kidney-shell	Ptychobranchus phascolus	
Spike	Unio gibbosus	
Paper-shell	Lampsilis gracilis	
Sugar-spoon	Truncilla arcæformis	(b)
Oyster mussel	Truncilla perplexa	
Rabbit-foot	Quadrula cylindrica	
Bullhead	Pleurobema æsopus	10.00
Similar to niggerhead	Quadrula subrotunda	15.00
Ringed pimple-back	Cyprogenia irrorata	15.00
Fan-shell	Dromus caperatus	20.00
Fork-shell	Truncilla lewisii	

[a] "Yellow mucket" may include also specimens of *L. orbiculata;* "green-striped mucket" may include both *L. ligamentina* and *L. ligamentina gibba.*
[b] Of value for souvenir or fancy articles.

Seven valves, or three and one-half complete shells, give a weight of 1 pound, and produce 8 dozen button blanks, according to which test 100 pounds would produce a little more than 57 gross of 168 blanks per gross. Estimating the material at a conservative figure of 7 cents a gross makes the value of 57 gross $3.99, or the value of the blanks from a ton of shells $79.80. The black muckets are not equal in quality to the other muckets, which are indeed exceptionally fine. The black muckets show many spots which would cause considerable waste. Yellow muckets and green-striped muckets constituted 40

per cent of the catch, while 20 per cent were large black muckets and 20 per cent three-ridges. It will be understood that the valuation was based on the contemporary market, that a number of species were not tested out, and that the figures are to be taken as being only approximately correct.

A later and more careful valuation of species is given below:

Common name.	Scientific name.	Number blanks per pound of shells.	Gross per ton.	Size of blanks.	Value per gross.	Value of blanks per ton of shells.
				Lines.	*Cents.*	
Yel ow mucket	Lampsilis ligamentina gibba	93	1,107	20	7	$77.49
Mucket	Lampsilis ligamentina	37	440	20	5	22.00
Flat niggerhead	Quadrula coccinea	61	799	18	3	23.97
(Not given)	Species uncertain	33	392	20	4	15.68

HOLSTON RIVER, NEAR STRAW PLAINS, TENN.

After a week spent in completion of the investigation in the vicinity of Morristown, a visit was made to Straw Plains, Tenn., where it was understood that a pearl fishery was prosecuted. The Holston River had then risen about 2 feet and the water was very yellow and muddy. Heaps of mussel shells were observed on the banks, but the fishermen had left this place and were found at a point on the river 3 miles above Straw Plains.

Observations were made of the piles of shells about the camps of the fishermen; the shells looked quite fresh, but were then partly submerged by the rise of the river. Unfortunately, it was not possible to work on the beds in the river, since no sound boat was available. It was noted that about 65 per cent of the shells taken by the pearlers were good muckets of like value with those collected at Three Springs. The niggerhead shell occurred in the proportion of about 15 per cent, while other species were present in limited quantities. A considerable number of the shells were taken to Knoxville, where there was opportunity to sort and observe them more carefully.

The following is a list of species collected:

Species of Mussels Collected in Holston River, Near Straw Plains, Tenn.

Common name.	Scientific name.	Common name.	Scientific name.
Pig-toe	Quadrula obliqua.	Kidney-shell	Ptychobranchus phaseolus.
Golf-stick	Obovaria retusa.	Fluted-shell	Symphynota costata.
Black sand-shell	Lampsilis recta.	Pimple-back	Quadrula pustulosa.
Elephant-ear	Unio crassidens.	Long pimple-back	Quadrula pustulosa.
Niggerhead	Quadrula ebena.	Sugar-spoon	Truncilla arcæformis.
Pocketbook	Lampsilis ventricosa.	Large mucket	Lampsilis ligamentina.
Three-ridge	Quadrula undulata.	Green-striped mucket	Lampsilis ligamentina.
Purple pimple-back	Quadrula tuberculata.	Yellow-back mucket	Lampsilis ligamentina gibba.
Fan-shell	Dromus caperatus.	Spike	Unio gibbosus.
Hatchet-back	Lampsilis alata.		
Paper-shell	Lampsilis gracilis.		

HOLSTON, FRENCH BROAD, AND TENNESSEE RIVERS, NEAR KNOXVILLE, TENN.

Through the kindness of Mr. Curtis, a jeweler and pearl dealer in this city, there was opportunity to examine a valuable local collection of pearls and baroques. It was desired also to examine the French Broad River, near its union with the Holston River, where they form the Tennessee, and a boat and competent guide having been secured, Mr. Boepple proceeded up the French Broad a distance of 5 miles to the shoals. The beds were then examined by working down stream. With each haul four to six mussels were obtained, chiefly the elephant-ear. It was reported that at a distance of 20 miles up this stream a large proportion of good white shells were obtainable.

After entering the Tennessee River similar conditions prevailed, only elephant-ears and a very few white shells being taken. It was learned that below Knoxville there was a shoal with gravel bottom where many mussels were to be found, but without pearls. Consequently the local informant had no knowledge of the varieties of the shells constituting this bed. A few days later it was found practical to visit the shoals referred to. A haul was begun at a point 200 feet above the shoals and continued through the shoals into the quieter water below. Each haul extended over a distance of 20 to 50 yards and each time 12 to 24 mussels were taken on a drag bearing 48 hooks. This was the condition just above and on the shoals. Mussels were obtained throughout the entire width of the river, and some were taken in the quieter water below. After the boat was filled with mussels, a count showed that 90 per cent were elephant-ear and 10 per cent pig-toes, muckets, and others.

The elephant-ears have no value, pig-toes were of the same value as corresponding shells of the Ohio River. The monkey-face corresponds in value to the pig-toes; white pimple-backs were comparable to niggerheads in value. Muckets were of poor quality, the shells being so thin as to produce chiefly tips, while the thicker part had little luster, was chalky, and accordingly not susceptible of polish. They were also partly spotted. A list of shells taken in the vicinity of Knoxville is given below:

SPECIES OF MUSSELS COLLECTED IN VICINITY OF KNOXVILLE, TENN.

Common name.	Scientific name.	Common name.	Scientific name.
French Broad River.		*Tennessee River, 4 miles below Knoxville.*	
Elephant-ear	Unio crassidens.	Elephant-ear	Unio crassidens.
Mucket	Lampsilis ligamentina.	Pig-toe	Quadrula obliqua.
Pig-toe	Quadrula obliqua.	Mucket	Lampsilis ligamentina.
Niggerhead	Quadrula ebena.	Monkey-face	Quadrula metanevra.
Tennessee River below the Forks.		Pimple-back	Quadrula pustulosa.
Elephant-ear	Unio crassidens.	Purple pimple-back	Quadrula tuberculata.
Mucket	Lampsilis ligamentina.		
Pig-toe	Quadrula obliqua.		
Pocketbook	Lampsilis ventricosa.		

The French Broad River is described as being navigable, the channel having been improved in some places through the construction of dams by the Government; the bottom is coarse gravel; in places the river is bordered by farm land, while in other places steep cliffs of rock border the stream. Marble quarries were noted. Marble banks were also observed along the Tennessee River, while the bottom of the stream was a coarse gravel.

The presence of marble or limestone along the banks or the bed of a stream constitutes a most favorable factor for mussel growth, since the erosion of the rocks keeps the water supplied with the carbonate of lime, which is the principal constituent of the shell. The stream was quite large and, except on the shoals, quite deep; there were places where the bottom could not be reached with a sounding pole 10 feet in length. Not one mussel was observed to be gravid, although it was thought that the mussels of some species were preparing to spawn.

It was found that pearls were bought and sold on the streets of Knoxville. Private collections were also observed, and a wide variety of pearls and slugs of good quality were seen. Since it was learned that most of the pearls come from the Clinch River, Mr. Boepple proceeded at once to make an examination of the mussel beds of that river from Dutch to Clinton, Tenn.

THE CLINCH RIVER FROM DUTCH TO CLINTON, TENN.

Investigations on the Clinch River were begun October 25, 1909, at Dutch, Tenn., near the railroad bridge, where shells could be taken by wading. The water was sufficiently clear to distinguish mussels on the bottom at a depth of 2 feet, but they were found to be very scattering. At the Sycamore Shoals fishing was undertaken with the rake. Chiefly small mussels were found both above the shoal and in the shoal, but not immediately below.

The bottom of the river here was of rough gravel and sand; there were a good many reefs ("hogbacks") and in some places the rocky bottom took the form of steps, over which it was difficult to work the small boat. Between the reefs the water was so clear that mussels could be seen at a depth of 4 feet. On both banks were bluffs of limestone rock.

The following mussels were found to be in breeding condition: Muckets (*Lampsilis ligamentina*); yellow-back muckets (*L. ligamentina gibba*); pocketbook (*L. ventricosa*); a small mucket, species uncertain; a fluted-shell (*Symphynota costata*); oyster mussel (*Truncilla perplexa*); the black sand-shell (*L. recta*). Large numbers of mussels discarded by the pearl fishers were observed in the river, and a little farther down were piles of shells on the banks containing as much as 2 tons, 75 per cent of which were shells of the best muckets.

The investigation was continued by working down the river in a small rowboat with a competent local guide. On the following day, after collecting on many small shoals, the party reached Walker's ferry, where a remarkably abundant mussel fauna was encountered. Although the water was very clear it was difficult to see the mussels on the bottom, and they were best taken with the rake. Several tests were made by digging holes in the bottom, and mussels were found in every case. In one instance a hole 2 feet wide by 2 feet long was excavated for a depth of 10 inches, and 66 mussels, representing 10 different species, were taken. This represents an average of 16 mussels to the square foot of bottom surface, a very remarkable degree of abundance.

The following table indicates the approximate proportions in which the chief species occurred:

	Per cent.
Mucket	30
Long niggerhead	10
Fluted-shell	20
Pig-toe	10
Various small species	30

A little farther down the river deeper water was encountered and the crow-foot dredge was employed to advantage, taking large muckets and pocketbooks. As before, mussels were found just above the shoals and on the shoals. In every small shoal examined in this vicinity it appeared that the greater part of the best shells had been opened and thrown away by the pearl hunters. Although the shells were muddy and dirty, they were found to be in good condition for button manufacture.

The commercial value of such shells was explained to the pearl hunters, who were advised to seek a market for this material. It was learned that few pearls had been found during the preceding summer, so that a market for the shells was practically necessary to supplement the income from the yield of pearls. It was estimated that about three-fourths of the open mussels were of good commercial value and that 2 carloads of shells could be obtained in the immediate vicinity.

The character of the bottom of the river and banks corresponds to that hitherto described. The following species were observed to be in breeding condition: Mucket (*Lampsilis ligamentina*), pocketbook (*L. ventricosa*), black sand-shell (*L. recta*), fluted-shell (*Symphynota costata*), oyster mussel (*Truncilla perplexa*), sugar-spoon (*T. arcæformis*), kidney-shell (*Ptychobranchus phaseolus*), and others.

Large piles of shells made by the muskrats were examined on an island, where it was noted that about one-third of the shells were the spectacle-case (*Margaritana monodonta*). From this point down, the spectacle-case was found to be more abundant than before. Long

Meiers Shoal was found to have abundant mussels, and on other shoals several miles lower on the river, where the water was shallow (6 to 18 inches deep) and rapid over a rough bottom, there were observed large numbers of the best shells, which had been recently discarded by pearl hunters. Examination of the bottom by means of the rake was made in many different places, but practically no shells were found except the finest muckets. It was estimated that a carload of shells could be obtained in that vicinity.

At a point 5 miles lower, where the river bottom was composed of rocks and small gravel, mussels of large size were found. On the 29th, Cloud Shoals was reached and investigated. On account of the compactness of the bottom, the rake formerly used was discarded for a common pitchfork, with which the mussels could be more easily obtained. Various species were found, but the chief shell was the mucket. Elephant-ear and fluted-shells were observed to be decreasing in abundance the farther the investigation was continued down the river.

A little lower on the river a pearl hunter was observed taking the mussels by the rather crude method of using an iron hook to pry the mussel from the bottom and push it into a tin can that was lowered to the bottom. He reported that pearls were more frequently found in mussels taken from the deep water, possibly because the older and larger shells were to be found in such a location.

Mr. Boepple was informed of a unique method of mussel fishing sometimes pursued in that vicinity. By using a plow drawn by a strong team and working where the water had a depth of 4 to 12 inches, the bottom is thoroughly plowed up so that the mussels can easily be picked from the surface.

Another good mussel shoal was found just before reaching the mouth of Powell River, a short distance from Agee.

A brief examination was made October 30 of the lower portion of the Powell River, the bottom of which, in this region, is described as being of limestone and gravel. One bank is rocky, with high bluffs, while the other is bordered by good farming lands. Mr. Boepple employed a pair of tongs, somewhat similar to blacksmith's tongs, with which he could work in 5 feet of water. The chief mussels taken in the lower portion of the river were three-ridges and fluted-shells. A little higher up a great many muckets, black sand-shells, three-ridges, and hatchet-backs were encountered. Three pearl fishers working together in one boat were found prosecuting their work, two men manipulating the boat, while the third collected the mussels, using a small fork with long handle.

The mussels of the Powell River have not so high a commercial value as those of the Clinch. The muckets, which were mostly old mussels, constituted about one-fourth of the shells. The three-ridges were listed as without commercial value.

Working at a point on the Clinch River a quarter of a mile above its mouth, it was observed that along the banks chiefly small mussels were found, while in the middle portion of the river large examples of muckets, niggerheads, and pocketbooks could be taken. The shells were found in the bottom at a depth of from 1 to 10 inches; it was thought that the mussels buried themselves on account of the low stage of the water. Below Agee the bottom was composed mostly of large rocks instead of shoals and gravel, the mussels lying between the rocks. Many fine large mussels could be taken by using the tongs.

As the investigation was continued down the river, October 31 and November 1, many shoals were examined, as well as the piles of mussel shells made by muskrats or by pearl hunters along the river banks. Pearl hunters were observed taking mussels with the use of a long stick, which was inserted into the opening of the shell and upon which the mussel would close and hold with sufficient firmness to be brought up to the surface. Small dip nets were used to pick up mussels that were lying on the rocks. Another method was the use of a long pike-pole, on the handle of which was a steel spring which could be pushed down over the mussel. At this point, only a short distance above Clinton, the three-horned warty-back, golf-stick, and butterfly were first encountered.

About 1½ miles above Clinton a shoal called Moores Ferry was carefully examined. On one side the bottom was composed of a very soft gravel, in which no mussels were found. About 50 feet from the bank, however, the gravel was firmer and there were mussels. On the whole, very few mussels were taken, and it was thought that the beds were practically exhausted as the result of the persistent fishery in the region of Clinton. Lower down the river piles of mussel shells were found, which had been taken by pearl hunters working where the water had a depth of 10 to 15 feet.

COMMERCIAL VALUE OF MUSSELS FROM THE CLINCH RIVER.

Mr. Boepple rated the mussels of the Clinch River as having particularly high market values. The niggerhead is not quite so good as the Ohio River niggerhead, but it should bring a fair price. The pig-toe of the Clinch River is of much better quality than those of the Ohio River; the black sand-shell is of extra fine quality. The sugar-spoon and oyster mussel could be used for very small buttons; the white pimple-back is of moderate value, and the fan mussel produces good buttons, though its color in this region turns to common pink. Mr. Boepple made the following statement in his notes: "The Clinch and Holston Rivers have the best mussels for buttons that I have seen in all my experience in the button business."

The following table includes the result of commercial tests of shells taken from the Clinch River near Clinton, Tenn., and from

Powell River. The diameter of blanks is expressed in "lines" (1 line = $\frac{1}{40}$ inch), and "T" in the columns indicates "tips," uneven blanks of poor quality.

COMMERCIAL VALUATION OF MUSSEL SHELLS TAKEN FROM CLINCH AND POWELL RIVERS.

Common name.	Scientific name.	Quantity of shells tested.	Number of blanks obtained.	Number of gross blanks estimated per ton.	Size of blanks.	Value per gross.	Value of blanks per ton of shells.	Number of shells (pair) used for test.
CLINCH RIVER.								
Anderson County near Clinton.								
		Lbs.			*Lines.*	*Cents.*		
Bull head	Pleurobema æsopus	½	22	523	20	4	$20.92	5½
Kidney shell	Ptychobranchus phaseolus	2	164	976	16	2	19.52	14
Pig-toe	Quadrula obliqua	2	8	46	36	18	8.28	9
		2	9	53	30	12	6.36	9
		2	47T	279	16	1	2.79	9
Ringed warty-back	Cyprogenia irrorata	2	18	107	30	10	10.70	13
		2	58	345	18	3	10.35	13
Pocketbook	Lampsilis ventricosa	2	60	357	24	5	17.85	5
		2	69	410	16	1	4.10	5
Black niggerhead	Quadrula coccinea?	2	82	488	20	6	29.28	([a])
Pig toe	Quadrula obliqua	1	38	452	20	4	18.08	5
Yellow-back mucket	Lampsilis ligamentina gibba	5	142	338	24	8	27.40	9
		5	311	740	20	7	51.80	17½
Black sand-shell	Lampsilus recta	2	20	119	24	4	4.76	......
		2	148	880	16	2	17.60	......
Union County.								
Pimple-back	Quadrula pustulata	1	82	976	16	3	29.28	......
Yellow-back mucket	Lampsilis ligamentina gibba	5	360	857	20	7	59.99	19½
		5	46	119	35	15	16.35	10
		5	118	280	20	6	16.80	10
Pocketbook	Lampsilis ventricosa	2	89	529	20	3	15.81	......
Grandma	Lampsilis ovata	2	94T	559	16	1	5.59	......
Black sand-shell	Lampsilis recta	1	10	119	24	4	4.76	......
		1	71	845	18	3	25.35	......
Grainger County.								
Black sand-shell	Lampsilis recta	1	16	190	24	4	7.60	......
		1	57	678	16	2	13.56	......
	Quadrula coccinea	1	67	799	18	3	23.97	......
	Quadrula coccinea, small	1	124	1,476	16	2	29.52	......
Ringed warty-back	Cyprogenia irrorata	1	48	571	20	4	22.84	......
POWELL RIVER.								
Campbell County.								
Three-ridge	Quadrula undulata	5	204[d]	485	20	2	9.70	......
Black sand-shell	Lampsilis recta	1	10	119	24	4	4.76	......
		1	68T	800	18	1	8.00	......
Yellow-back mucket	Lampsilis ligamentina gibba	5	19	45	35	15	[b]6.75	......
		5	140	326	20	5	[b]16.30	......
		5	45	107	30	12	[c]12.74	......
		5	228	542	20	4	[c]21.68	......

[a] Not stated. [b] Large. [c] Small. [d] Second grade blanks and tips.

It will be noted from the above table that the same lot of shells was in some cases tested for two sizes of blanks, as in the case of the last lot of *L. ligamentina gibba*, or yellow-back mucket, shown in the table. The shells were first tested for 30-line buttons, and the

value of the blanks obtained was estimated to amount to $12.74; the remaining parts of the same shells were then used again, cutting out 228 blanks and tips of 20 lines and the value of these was estimated at $21.68 per ton of shells. Thus, if the shells were worked twice for the two sizes of blanks, the total value of the product obtained would be $34.42 per ton. The shells were not especially selected for testing and the results should give an approximately correct idea of the commercial value of the mussels of the Clinch River from the region investigated, after making all necessary allowances for handling, transportation, etc.

As far as known no shells had been shipped for the button market prior to the time of Mr. Boepple's investigation, although at that time some shells were being collected near Clinton, and a single car of shells reached the market late in that season, 1909. Pearls had been sought for a great many years, but the value of the shells was entirely unappreciated. It required some time, in fact, for the residents to realize that this neglected resource was of substantial value. In the following seasons, 1910 and 1911, several carloads were collected and sold for button manufacture. During the season of 1912, as is understood, the search for shells is being pursued with greater vigor, even up into the headwaters of these rivers, in the Appalachians, and it is expected that larger shipments will be made.

The streams are small and can not make a significant bulk yield, but the quality of the shell product, as well as the value of the pearls, is such as to justify careful attention to the fishery and the proper protection of the beds from depletion.

ALASKA FISHERIES AND FUR INDUSTRIES IN 1911

BARTON WARREN EVERMANN
Chief of Alaska Fisheries Service

Bureau of Fisheries Document No. 766

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ALASKA FISHERIES AND FUR INDUSTRIES IN 1911.

GENERAL ADMINISTRATIVE REPORT.

By Barton Warren Evermann, *Chief, Alaska Fisheries Service,*
and
F. M. Chamberlain, *Agent, Alaska Salmon Fisheries.*

The Alaska salmon service and the fur-seal service, established in the Treasury Department the year following the purchase of Alaska, were transferred to the Department of Commerce and Labor by the act of Congress of February 14, 1903, creating that department, the transfer becoming effective July 1, 1903. By order of the Secretary of Commerce and Labor, then Hon. Victor H. Metcalf, the Alaska salmon service was placed under the immediate supervision of the Bureau of Fisheries February 15, 1905; and by order of the succeeding Secretary, Hon. Oscar S. Straus, under date of December 28, 1908, the "general management, supervision, and control of the execution, enforcement, and administration of the laws relating to the fur-seal fisheries of Alaska" were placed with the Bureau of Fisheries. The "Act to protect the seal fisheries of Alaska, and for other purposes," approved April 21, 1910, gave the Secretary of Commerce and Labor jurisdiction over all fur-bearing animals in Alaska, and these duties the present Secretary, Hon. Charles Nagel, at once placed with the Bureau of Fisheries.

The act making appropriations for the sundry civil expenses of the Government for the fiscal year 1912, approved March 4, 1911, established the "Alaska Fisheries Service," to include the Alaska salmon fisheries service, the fur-seal service, and the service relating to other fur-bearing animals.

The reports of the salmon and seal agents, therefore, hitherto published separately, will now be included, with the reports on remaining branches of the Alaska Fisheries Service, under one cover, the detailed statistical and descriptive portions, as furnished by the respective agents, supplementing the general administrative report of the year's activities.

FISHERIES.

INSPECTION OF SALMON FISHERIES.

With the exception of arctic Alaska, nearly all of the general localities in which important fishery operations are conducted were visited this year by one of the four agents engaged in the inspection work. For want of transportation facilities none of the packing establishments or fishery grounds on the Alaska Peninsula could be visited, with the exception of Chignik Bay, where one agent was located for the season. Another agent was located on Nushagak Bay, where his time was fully occupied with the inquiry carried on in connection with Wood River. In central Alaska, points about Prince William Sound and the Copper River had to be omitted. In southeastern Alaska a more efficient inspection was made, and with the exception of Dry Bay, the territory was well covered, for although there are many more places to be visited, the number of common carriers available enabled the agent to make more advantageous use of time. A fishery to supply local demand is carried on in the Yukon River and its tributaries, by means of fish wheels, nets, and spears, but it has not been possible to extend the inspection work over this large area, or to secure specific data. Arctic Alaska has not been visited, but such incomplete data for this section as could be secured are shown.

Detailed statistics of the fisheries are contained in the report of Mr. John N. Cobb, assistant agent, which appears in subsequent pages of this publication.

COMPLAINTS AND PROSECUTIONS.

On Sunday, July 9, fish traps no. 1, 2, and 3, belonging to the Alaska-Pacific Fisheries, operating in connection with its Chilkoot cannery, and trap no. 2, belonging to the Taku Canning & Cold Storage Co., of Taku Harbor, all in Lynn Canal or connecting waters, were found fishing in violation of the weekly close season, and Abel Johnson, the web boss, Thomas Johnson, Edward Meland, and John Loseth, trap watchmen for the Alaska-Pacific Fisheries, and Axel Strom, watchman for the Taku Canning & Cold Storage Co., were reported to the district attorney. All the defendants were arraigned before the United States commissioner at Juneau on July 11, and were bound over to appear before the next grand jury. On October 25, the grand jury, then in session at Ketchikan, returned true bills against all the defendants. John Loseth, Edward Meland, Thomas Johnson, and Abel Johnson pleaded guilty, and the three first named were fined $75 each, while the latter, against whom there were three indictments, was fined $150 under each. Axel Strom, the other defendant, agreed to appear at the next Juneau term of court and plead guilty.

On Sunday, August 6, Alaska Packers' Association trap no. 1, located in Behm Canal, near Cape Camano, was found in partial fishing condition, and on August 7 John Coyne, the head watchman, was arraigned before the United States commissioner at Ketchikan, and bound over to the next grand jury. The case was presented to the grand jury on October 23, but that body reported no true bill.

On June 27 a complaint was lodged in the court of the United States commissioner at Seldovia by Charles Miller, alleging that John and Andrew Wik had unlawfully begun the construction of a fish trap upon a site occupied by him for set nets. The evidence produced, however, showed that at the time the construction of the trap was begun the complainant had no stake net nor any part of one on the site in issue. The court decided that the trap was not unlawful and that previous occupancy by the complainant did not bring defendant's action under the act of 1906.

In November a Japanese fisherman, Miyata, was charged before the United States commissioner at Ketchikan with violation of the act (approved June 14, 1906) to prevent aliens fishing in the waters of Alaska. A statement of facts was agreed upon and the matter presented to United States Judge Thomas R. Lyons, who ruled adversely to the contention of the agent of the Bureau.

In November 21 Japanese were arrested, charged with fishing during the weekly close season. The alleged offense occurred in Yes Bay, southeast Alaska, and the defendants were fishing for herring with purse seines. After a hearing before the United States commissioner at Ketchikan all were bound over to the next grand jury, which will not meet until early in 1912.

SALMON RESERVATIONS.

GENERAL QUESTION OF SALMON FISHERY REGULATION.

Before the most intelligent regulations can be established for the insurance of a continuous supply of salmon, several questions remain to be definitely answered. As yet the fundamental propositions on which legislation is based are hypothetical, deduced from the general knowledge and beliefs as to the various species of salmon and their relatives rather than inductions from known facts.

Among the most practical questions still unanswered may be stated these:

1. Do all species of salmon regularly return to the home stream, i. e., the waters where hatched; or are they diverted at any time by adverse winds, food conditions, etc.?

2. May the run in a stream be built up by closing the stream to fishing, and if so to what extent?

3. What is the normal age of each species and what period is spent in fresh water?

4. What percentage of fry under normal conditions is produced from eggs deposited naturally?

5. Are any disadvantages suffered by fish artificially hatched?

In support of the proposition that salmon do return to the parent stream there still stands the admitted fact that given streams, at least in many instances, produce an average fish of a size different from that of neighboring streams. There are two ways to account for this fact. One, that these fish are a particular breed produced by the special environment; the other, that fish of a given size elect certain streams. The only positive solution lies in the marking of a sufficient number of fingerlings so that they may be recognized on return as adults. The marking done at Loring in 1903 was on too small a scale to be conclusive. It is believed, however, that it is safe to assume that some of the Loring marked fish were taken at Yes Bay about 30 miles distant. The runs at those two streams are of the same character and their adjacency makes it reasonable to doubt any sharp line of demarcation between them. The straggling "marked" fish turning up from time to time can hardly be regarded as of the marked lot. Fins may occasionally be lost by natural causes, that is by disease, and the advertising which the discussion has brought about leads to a much closer scrutiny now than formerly.

It is held, particularly in Bristol Bay, that winds have a very controlling influence on the run of salmon. Whether under any conditions runs headed for Nushagak Bay could be so deflected as to send them, for example, to the Kvichak or Naknek is not known.

Even the most careful comparison for a large number of years of the catches in these adjacent streams would not be conclusive, since the escape may vary greatly. But such a comparison would, if taken in connection with the gear operated and the weather, help greatly toward a solution. In this connection attention is called to the desirability of keeping accurate data of the fish caught and the gear used so that such compilations may ultimately be made. These figures would necessarily come from the various persons and companies fishing, and as it is precisely for their advantage that the facts should be known, self-interest would require the most conscientious effort to assist in their compilation.

The question of building up the run of salmon in a given stream by establishing a close season has had some light thrown on it by the results at the Afognak Reservation, and at the Naha Stream in southeast Alaska. The stream at Litnik, Afognak Island, has been legally closed since 1892, nearly 20 years, yet in 1911 only about 26,000 fish could be secured for the hatchery. The experience at Callbreath's plant on Etolin Island, where an accurate census of

incoming fish was kept, showed that approximately one-third of the fish entering the lake were never recovered for spawning. They spawn about the shores, remain in deep water until after the season, or in some way are lost.

Granting then that the number of red salmon entering Litnik Lake was 40,000, this does not show any remarkable effect from the closure. It was reported that when fished this stream was good for from 10,000 to 15,000 cases. They are a rather small fish and may be figured at 13 to the case, or a total output of 130,000 to 195,000 fish. On its face this makes a very bad showing, but there are two facts to be noted: First, that this stream was fished by a barricade resulting in not only the maximum catch, but an almost or quite complete extinction of the spawners; second, that although closed by law there was no official present to administer the law and a certain amount of poaching was carried on during the years preceding 1907, the year the hatchery was established. The extent of this illegal fishing it is impossible to determine. For these reasons it would be manifestly unfair to take Litnik Stream as an example of the results of an effective closing of a stream to fishing.

The Naha has been closed for about half this period, during which time a hatchery has been operated. Until 1911 all the fish that could be secured in the upper or principal lake were taken for hatchery use, so an examination of the hatchery record furnishes an approximate idea of the run. The year 1906 marked the first big impulse, but contradictory to the theory of building up an isolated stream by attention to it exclusively, the years following 1906 (except 1911) show a smaller take than those just preceding. For example, for the three years 1903, 1904, and 1905, the average take of eggs was 52 million, whereas in 1907, 1908, 1909, and 1910, the average was only 38 million. Thus it is seen that artificial as well as natural production has failed to elevate the output of an isolated stream above the normal level for the region. This in no wise demonstrates either that the protected natural production or the hatchery work has been without effect; it is easily conceivable that any increased output has been distributed to the point of being lost from sight. The figures only emphasize the necessity of arriving at positive knowledge before advocating this or that measure or recommending expenditures for particular purposes. Some of the questions regarding hatcheries are fully discussed in another section of this report.

The average age of the salmon is now in a fair way to be determined. Following the remarkable work of the Scotch and Norwegian investigators on the Atlantic salmon, a study of the scales of the various Pacific salmons has been undertaken. A careful examination of the scales reveals not only the number of years' growth, but also the period spent in fresh water before going to sea. Areas

of growth are marked by the distribution of lines on the scale somewhat as in the growth of rings of trees, and these appear to furnish an almost infallible index to the life of the fish. It is now known that not all of a species mature at the same age, but the proportion that are normal greatly overbalances the remainder. A more complete study of the age problem may throw light on the runs of undersized fish in such streams as the one at Necker Bay. It has been found in the study of the salmon of Norway that it matures later in northern waters than in southern. It is not improbable that a similar condition obtains in the Alaska salmon; and even if the normal age of the Fraser River sockeye is 4 years, that of the Alaska sockeye may be 5. This ability to determine the age of any particular fish will be of incalculable value in checking the results of marking experiments.

It is to be deplored that no definite data have ever been acquired as to the effectiveness of natural spawning. This, with the "parent stream" proposition, is the crucial point in the salmon question. It is true that this effectiveness must vary as widely as do the conditions under which the spawning is done, but a series of careful tests would determine what the normal output should be under any given conditions. It is not improbable that a general undervaluation of natural productivity and a corresponding overestimate of the results to be expected from hatchery work is responsible for the one time widely diffused belief that the presence of a few hatcheries would cure all the ills of an unremitting pursuit of salmon; while, now that the few hatcheries in operation do not seem to accomplish this miracle, the opposite tendency to decry all hatchery work is supplanting the former extreme optimism.

The hatchery can cover but one period of danger to the fish—that between the extrusion of the egg from the mother fish and the entrance of the fingerling upon its struggle for existence. In all its subsequent career it is at the most on a par with its naturally produced neighbor, granting it is equally as capable. That hatcheries alone can not substitute for overfishing, destruction of spawning beds, deforestation, and pollution of waters is shown by the experience with the Atlantic salmon. However many hatcheries may be established, adequate limitations on the fishery and protection of natural production must be conjoined. Whether a certain curtailment of the number of spawners allowed to reach the beds is advantageous is yet unanswered. Nature has her own checks to prevent dominance of certain species, and the loss on the spawning beds due to overpopulation may be one of these. Admitting that a fraction only of the adult fish is sufficient to continue the supply, the question arises, Which fraction? Shall the early run, or the late run, or a distributed run effected by weekly

close seasons be permitted to spawn? The canner in the field will answer, "The late run," for then he can close down his plant and return home. The correct answer awaits the solution.

The question of relative strength of hatchery fry and natural fry is as yet mere matter of speculation. As in most of these final questions, it will be determined by marking the fish. The suggestions regarding the proper planting of fry made in another section of this report answer most of the logical objections that have been advanced. It may ultimately be shown that the economical method of protected propagation is that by burying the eggs in gravel, as recommended by Mr. John Pease Babcock.

OBSERVATIONS IN WOOD RIVER REGION.

In the act of 1906 provision was made for the reservation of streams and lakes from fishing for the purpose of allowing salmon to increase in number. At present the only action in effect under this law is the closing of Wood and Nushagak Rivers by order of the Secretary of Commerce and Labor on December 19, 1907. Since this time there has been no fishing in those streams, nor within 500 yards of the mouths thereof, except that authorized in 1911 as a scientific test of the run of salmon in the Nushagak River. Although this order has in at least one case put the companies to some increased cost in making their packs, their acquiescence has been cheerful and without evasion. This exemplifies the almost universal desire on the part of the salmon packers to observe the laws and regulations established in the interests of the industry.

The observations carried on since 1908 at Lake Aleknagik were continued during 1911. There was no change in the number of canneries operated in Nushagak Bay or in the apparatus for capture used by them. The dates of the run did not vary from those heretofore observed. The count at the rack and the catch in Nushagak Bay, exclusive of the Egushik River, are shown in the following table:

RED SALMON RUN IN NUSHAGAK BAY AND TRIBUTARIES, 1908 TO 1911.

Years.	Nushagak Bay catch.	Wood River tally.	Total.	Per cent of escape.
1908	6,144,000	2,600,000	8,744,000	30
1909	4,687,000	893,000	5,580,000	14.2
1910	4,342,000	670,000	4,912,000	13.5
1911	2,846,000	354,000	3,200,000	11

It is seen by this table that the run of this species in the Nushagak Bay region has fallen off very materially in the three years since 1908. With this has been a greater proportionate decrease in the escape of spawners; the percentage fell from 30 in 1908 to 11 in 1911.

To test the run of red salmon in the main river in 1911, two gill nets were, through the courtesy of the Alaska Salmon Co., maintained in the mouth of that stream throughout the season. The number of red salmon taken in these two nets between the 4th and 29th of July was only about 3,000. The very great similarity of the dog salmon to the red may have made some error in this count, but if so it is on the side of indicating a too large count of reds. The test shows conclusively that a comparatively small run of reds ascended the Nushagak in 1911. The catch by the Indian stake nets along the river adds to this evidence.

The tally at the Wood River (Lake Aleknagik) rack was as follows:

Date.	Number of salmon.	Date.	Number of salmon.	Date.	Number of salmon.
July 4	228	July 14	43,310	July 24	2,669
5	72	15	57,238	25	3,064
6	776	16	13,172	26	3,929
7	5,938	17	23,742	27	5,480
8	7,114	18	9,659	28	2,895
9	17,624	19	4,658	29	462
10	31,935	20	5,476	30	505
11	20,760	21	5,220		
12	31,213	22	6,434	Total	354,299
13	46,781	23	3,945		

A curious fact in this connection is the almost exact coincidence of the maximum run each year. In 1908 it occurred on the 14th of July, the three following years on the 15th. Another peculiar feature of the situation in this region is that the favored stream, Wood River, is several degrees lower in temperature than the Nushagak. In southeast Alaska it holds as a general proposition that the redfish streams are the warmer, due to the effect of the lakes in their courses. This is so universally the case that, barring some streams with a disturbing glacial influence, an observer can determine with reasonable certainty whether a given stream is a red-salmon stream or not by applying a thermometer. The exceptions, however, go far toward proving that the selection of streams by the red salmon is governed by some other factor than temperature.

The salmon fingerlings leaving Lake Aleknagik are exceptionally fine fish. The average length of nearly 200 measured was 111 millimeters. The average length of something over 400 red fingerlings taken at the mouth of the Nushagak was only 61 millimeters. Further, there is a greater diversity of sizes in the Nushagak fingerlings. They varied between the extremes of 40 and 86 millimeters; the Lake Aleknagik fingerlings between 90 and 133 millimeters. Neither of these lots could have been less than a year and a half old—that is, they must be fish that have passed one winter in the lakes after hatching. An examination of the scales of the Aleknagik fish does not indicate that they are more than one year from hatching. The

only way to account for the difference in size would seem to be by the different conditions under which the eggs and fry are placed. The Wood River system of lakes, of which Aleknagik is the first, offers ideal conditions in extent and depth of water and abundance of food for the growth of the young. The theory has been advanced that the adults from fish reared in deep lakes are larger than those from shallow lakes. This proposition hinges, of course, on the other that salmon return at least for the greater part to the stream where hatched. Throughout the season of 1911 at Lake Aleknagik from the breaking up of the ice late in June until the observers left at the end of July fingerlings were leaving the lake in schools. Quite a number of these small fish are destroyed by birds, the Arctic tern (*Sterna paradisæa*) being particularly destructive. These birds breed in small numbers in the vicinity.

The destructiveness of the spotted trout or charr (*Salvelinus malma*) could be well noted at Lake Aleknagik. Numbers of these fish came in with the run of salmon and could be taken on a hook by the use of salmon eggs as bait. In most instances when taken during the time a school of salmon fingerlings was migrating, a number, sometimes as many as 15, of these were found in the trout stomachs. Of a number of blackspotted trout of similar size taken under the same circumstances none contained young salmon.

A rather hasty examination of the scales of a small number of red salmon from the Nushagak region leads to the conclusion that the greater number of the adults return at 5 years of age. The prevalent belief, based largely on the Fraser River runs, is that the red salmon matures in the fourth year. On this basis it has been expected that 1912 would yield the returns from the big run of 1908. In the light of later observation this seems doubtful and indicates that not until 1913 will the new cycle begin to run. It is of the utmost importance to continue the observations on Wood River until some definite values are arrived at. A consideration of the catch as given in the reports for a series of years does not afford much ground for deductions as to periodicity in the runs. It was not until about 1900 that the large catches began to be made. From 1899 to 1911 the number of redfish taken in Nushagak Bay is reported as follows:

Year.	Number redfish.	Year.	Number redfish.
1899	2,517,436	1906	5,183,512
1900	4,234,533	1907	2,522,024
1901	5,401,051	1908	6,144,031
1902	4,725,715	1909	4,687,635
1903	6,159,189	1910	4,342,626
1904	3,381,612	1911	2,846,638
1905	6,757,819		

The first big catch, that of 1903, repeats itself in 1908, but the largest catch of all, that of 1905, did not show corresponding results in 1910. It may be that factors enter into the calculation that are not accounted for, or it may be that the overfishing began to tell after 1903 and there are to be no more extraordinary runs. The year 1907 was the poorest year in the history of the fishery, and if the five-year period is to show it will be marked by a practical failure of the fishery in 1912.

AFOGNAK RESERVATION.

The Afognak Reservation is set aside under presidential proclamation and extends to the 3-mile limit in salt water. While several salmon streams are found on the island, only two, and one of these to but slight extent, are used at present to supply the hatchery. While closed by law there has doubtless always been fishing in these streams, at least by the natives, acting, perhaps, under their supposed rights. Inasmuch as it can not be shown that this legal closure has resulted in material benefit to adjacent streams and as no interest could be subserved by the production of fish which no one was allowed to utilize, the department decided to remove the prohibition within certain limits for the benefit of the native inhabitants of the island until such time as the fish were otherwise required.

PROPOSED RESERVATIONS.

At the instance of interested persons the closing of the streams tributary to Cook Inlet, Eyak River and Lake, Anan Stream, and Naha Stream will be taken up for consideration. A hearing for this purpose has been set for October 18, 1912, in Seattle. This action is taken under the law of 1906 and if effectuated by an order closing these waters it will apply only to the streams, lakes, and the salt water within 500 yards of the river mouths. Up to this time protective measures have been addressed almost wholly to the red salmon. With the increased recognition of the so-called inferior grades their preservation must also be looked to. While it is true that the pink and chum salmon are widely dispersed, this does not insure their perpetuation. The run in small streams can be effectually wiped out by a few applications of a seine, and their isolation and relative unimportance are temptations to infraction of the law.

CHIGNIK BAY.

During the month of June a reconnoissance of lower Chignik Lake was made by the officers and crew of the steamer *Albatross*. The sketch of the lagoon made by the *Albatross* party in 1897 was found to be entirely too inaccurate to permit plotting the fish traps, but

other work demanded attention and no further survey by the vessel was possible.

An available site for a counting rack was surveyed and it is hoped that the experiment now under way at Lake Aleknagik may be repeated on this stream. Chignik being isolated from all other important salmon streams, it is an ideal location for a census of spawners.

This is the first season that an agent has been stationed at this place. Chignik is peculiar in the fact that most all the salmon are taken by means of traps, and for this reason the observance of the weekly close season is of prime importance. It was, in the main, carefully observed this year and natives report an unexampled abundance of spawning fish in the lakes.

MARKED SALMON.

Under date of March 17, 1908, the Secretary of Commerce and Labor addressed the following notice to owners and operators of salmon hatcheries in Alaska:

> The act for the protection of the salmon fisheries of Alaska, approved June 26, 1906, vests in the Secretary of Commerce and Labor the proper investigation, inspection, and regulation of the Alaskan fisheries. The department, through its salmon inspection service under the Bureau of Fisheries, intends to conduct through a term of years a series of investigations of the fisheries, particularly by marking and liberating salmon fry artificially hatched and examining the return of adults. Such markings have hitherto been made by various persons in Alaska. It is necessary in order that confusion of the results may be avoided that no further experiments of this sort be undertaken by the commercial hatcheries, or that none be made save by the permission of this department. It is therefore directed, under the authority of sections 11 and 12 of the Alaska fisheries law, that any persons desiring to mark and release salmon in Alaska first consult with and secure the written consent of the Commissioner of Fisheries or of the agent at the salmon fisheries of Alaska.

This regulation is still in force. At Yes Bay a number of salmon were caught during the season minus fins, thus indicating that they had been marked. A number of marked salmon were also observed at the Quadra hatchery.

THE GOVERNMENT AND ITS RELATION TO PRIVATE HATCHERIES.

Criticism has been made from time to time of the supervision exercised by the Government over private hatcheries in Alaska. In particular, the report of the grand jury sitting at Valdez in March, 1911, expressed this attitude. Reply was made by the Secretary of Commerce and Labor under date of May 2, 1911, in part as follows:

> Under the heading "Fisheries" this report comments on the provision of the present Alaska fisheries law providing for tax exemption on account of salmon fry liberated by packers maintaining hatcheries.

It is expressed or implied that the law deprives Alaska of a very considerable revenue; that there is laxity in the provision concerning proof of liberation, and in inspection and supervision of hatcheries that the law practically permits the canneries to name for themselves the sum they shall pay as taxes; that no certificate of inspection has been filed since 1906; and that there is no check on the number of fry liberated.

In the matter of proofs of liberation it is true that the law requires only the affidavit of hatchery owners or officers, but this does not leave the planting of salmon fry quantitatively unchecked. The agents at the salmon fisheries know the capacities of the respective hatcheries and have knowledge of the runs of salmon in hatchery streams. It is in every way to the interests of hatchery owners not only to take all the eggs available, to the extent of their capacities, but also to hatch and plant all the salmon fry possible from such eggs. Exaggeration of importance in affidavits conflicting with the known facts would be discoverable and would lead to revocation of approval. Salmon hatching operations follow a well-known routine and the affidavits of hatchery superintendents have thus far been consistent with the available take of eggs and with the losses to be expected between the taking of eggs and the liberation of fry. The inspection of hatcheries has been in accordance with the law and as frequent and complete as the inadequate force at the disposal of the department permits. The recent Congress has granted some additions to the personnel of the Alaska Fisheries Service, and instructions have already been issued for a thorough examination of all private hatcheries in Alaska during the coming season.

The canneries have never been able themselves to fix the sum that they shall pay as taxes. The tax is fixed by law on products, the quantities of which can not be successfully concealed. By fraud the tax exemption could perhaps be increased by petty amounts. No system of taxation could avoid this.

The grand jury declares that "no certificate of inspection of a hatchery has been filed with the clerk of the court in this division since the year 1906." This is quite in accordance with the law. It is not intended that approvals shall be reiterated annually—this would be supererogatory. Any approval once made stands until current inspections show cause for its revocation.

The principle of encouraging the operation of private hatcheries by remitting taxes on the commercial output of the fisheries is subject to criticism on the ground that the remission is discriminatory in that it favors the fishing industry solely, whereas the tax on other industries is of general benefit and therefore is in true sense a tax for revenue. In other words, the rebating system on the release of fry from private hatcheries is tantamount to no tax whatsoever so far as the people at large are concerned. The present rebating system is comparable to a plan of remitting the tax on mine stamps with the understanding that the amount so remitted be devoted exclusively to development work on prospective mining claims.

On the other hand, the advocates of the tax-rebating system for the release of salmon fry claim that the continuance of the fishing industry is in large measure dependent upon hatchery work and that it is no more than just that the few concerns maintaining hatcheries should be reimbursed for their work. This argument in itself is fair enough, and were there no diverse interests concerned in taxation, the proposition would stand unchallenged.

Since, however, there is another side to the question, it would seem that the only logical and equitable solution of the problem is Government ownership of all hatcheries in Alaska. This may be brought about by repealing the law providing for rebates and appropriating a sum sufficient for the Government to acquire the present hatcheries at a fair valuation and provide for operating expenses thereafter in current appropriation acts.

The existing rebating system in aid of private hatcheries has been subjected to much criticism. The rate allowed by law is such that while it covers generously the running expense of an established plant is not sufficient to induce any new ventures in hatching for profit. Only those hatcheries are now running which were in operation at the time the law was enacted and which had been erected in the faith that the results in increasing the number of fish would warrant the expense of their operations. At the time they were built, fishermen were firm believers in the parent stream theory and the sense of the word "millions" used in expressing the output of fry was perhaps unconsciously carried over into the estimates of profits.

As to inspection of private hatcheries by the Government, the wide separation of the various establishments and their isolation and relative inaccessibility render adequate inspection very difficult. Continuous inspection would require a resident inspector at each plant, while even frequent inspection would entail the employment of two or three inspectors actively throughout the season with large expense for travel. Living quarters for the Bureau's agents can be secured only by courtesy of the operating companies. Under such circumstances the main dependence is necessarily placed in the affidavit of the managers, and general knowledge of the size of the run at any given locality, the normal results of hatchery operations, general character of ability shown by employees, etc., in connection with actual inspection at least once during the season.

With the increase in personnel of the Alaska Fisheries Service, as stated by the Secretary of Commerce and Labor in the letter just quoted, a closer inspection was made than heretofore has been possible, and improvements have been instituted at the hatcheries as a result. A detailed report upon the hatcheries, by Mr. Ward T. Bower, appears on pages 67 to 89 herein.

NEED OF NEW HATCHERIES.

Undoubtedly there is urgent need of a hatchery in the Bristol Bay region, where for many years the drain upon the supply of salmon has been heavy. In the light of present information Lake Aleknagik, of which Wood River is the outlet, presents a suitable field for fish-cultural operations. No appropriation for this work, however, has been made as yet by Congress.

The erection of several hatcheries in southeastern Alaska would be of great benefit in that region, which has been and will continue to be heavily fished, and rather than 1 or 2 more large hatcheries it would be desirable to have 8 or 10 smaller establishments, even though the aggregate output thereof is no greater than from a single large plant. More streams would be protected and there is less possibility of a shortage in the supply of natural food. A capacity of from 5 to 10 million eggs would best suit the hatchery needs in several localities. This course is bound to insure a more thorough covering of the field and will consequently be of greater benefit to the industry.

Apparently the time is not far distant when the propagation of the heretofore practically neglected humpback salmon will be undertaken on an extensive scale.

FUR INDUSTRIES.

FUR SEALS.

The administration of the fur-seal service in 1911 followed the same general plan as in 1910 with respect to management of the seal herd, and yielded a shipment of skins amounting to 12,006 in number, 1,000 3-year-old male seals having first been marked and excluded from the killing. With respect to the affairs of the native inhabitants of the islands a new fiscal plan was adopted, whereby higher wages were paid and it is sought to encourage the individual native's responsibility for his own welfare. A detailed report upon the administration of the islands, by the chief resident agent, Mr. Walter I. Lembkey, is appended hereto.

SALE OF FUR-SEAL AND FOX SKINS FROM THE PRIBILOF ISLANDS.

When the Government, on April 21, 1910, took entire charge of all matters pertaining to the Pribilof Islands and the care and management of the fur-seal and blue-fox herds, the Department of Commerce and Labor at once began consideration of the proper method of disposing of the skins to be taken each year. After careful investigation it was decided to continue for the present, at least, the practice which had been in vogue for more than 40 years and ship the skins to London, there to be sold at auction.

For a long period practically all the fur-seal and blue-fox skins of the world, as well as all other furs, have passed through the hands of Messrs. C. M. Lampson & Co., of London, England, the firm receiving the skins on consignment and selling them at auction to the highest bidder. The sale day for the Alaska fur-seal skins is usually about the middle of December of each year. Northwest coast skins, as the

pelagic catch is designated, are usually sold at the same time or in January, rarely in March, while Copper Island skins (skins from the Asiatic herds), are generally sold in March. Alaska blue-fox skins also are usually sold about the middle of March of each year.

In accordance with the decision reached by the department the fur-seal and blue-fox skins taken by the Government on the Pribilof Islands in 1910 and 1911 were consigned to Messrs. Lampson & Co., by whom they were duly sold and the net proceeds of the sales paid to the United States Government.

The 12,920 sealskins taken in 1910 were sold December 16, 1910. The gross proceeds were $435,083.59, or an average of $33.68 per skin. The net proceeds of the sale were $403,946.94, for which amount C. M. Lampson & Co.'s checks were received for $402,840.50 and $1,106.44, respectively, by the Secretary of Commerce and Labor, and these amounts were by him covered into the United States Treasury. Under the leasing system the net receipts for that year would have been only $131,007.

The sealskin catch of 1911 was shipped to London and sold December 15, 1911, the gross receipts being $416,992.40 for 12,002 skins, or an average of $34.74 per skin. The net proceeds, $385,862.28, have been paid into the United States Treasury. Under the leasing system the net receipts would have been only $122,720.45.

No fox skins were taken by the Government until during the winter of 1910–11. For that season the catch consisted of 371 blue and 20 white fox skins, which were sold on March 18 and 19, 1912, by C. M. Lampson & Co. The gross receipts were $16,563.55, or approximately $9.71 per skin for the white and $44.12 for the blue skins. The net proceeds were $15,096.58, which amount was covered into the United States Treasury. The total net revenue from the Pribilof Islands in 1911 was thus $400,958.86.

Following is the detailed statement of C. M. Lampson & Co. of each of these sales (1910 and 1911):

Statement of Receipts and Expenditures on Account of Sale of Sealskins by C. M. Lampson & Co., London, December 16, 1910.

Certified check, Alfred Fraser, New York, December 30, 1910	$402, 840. 50
Certified check, Alfred Fraser, New York, January 19, 1911	1, 106. 44
	403, 946. 94

	£	s.	d.	£	s.	d.
Sale of 12,920 skins	89, 624	16	0			
Less 2½ per cent discount	2, 240	12	5			
				87, 384	3	7
Credit by 228 casks				35	3	0
Credit by salt				2	19	3
				87, 422	5	10

	£	s.	d.	£	s.	d.	
Expenses in connection with sale:							
Through freight	117	19	3				
Marine insurance	257	12	9				
Disbursements in New York	316	1	8				
Interest on above	6	12	1				
Commission, 4 per cent	3,496	17	10				
				4,195	3	7	
Net proceeds				83,227	2	3	
Interest on £227 2s. 3d., December 30 to January 19, 20 days					12	5	
				83,227	14	8	
£83,000 at $4.8545	$402,923.50						
Less $1 per £1,000	83.00						
				$402,840.50			
£227 14s. 8d., at $4.8595	1,106.67						
Less $1 per £1,000	.23						
				1,106.44			
Net receipts by above checks							$403,946.94

STATEMENT OF RECEIPTS AND EXPENDITURES ON ACCOUNT OF SALE OF SEALSKINS BY C. M. LAMPSON & CO., LONDON, DECEMBER 15, 1911.

	£	s.	d.	£	s.	d.	
Certified check, Alfred Fraser, New York, to order of Secretary of Commerce and Labor							$385,862.28
Sale of 12,002 skins	85,677	10	0				
Less 2½ per cent discount	2,141	18	9				
				83,535	11	3	
Credit by 212 casks				33	11	4	
Credit by salt				2	15	0	
				83,571	17	7	
Expenses in connection with sale:							
Through freight	132	2	0				
Marine insurance	494	3	11				
Disbursements in New York	297	10	11				
Interest on above	7	10	7				
Commission, 4 per cent	3,342	17	6				
				4,274	4	11	
Net proceeds				79,297	12	8	
£79,297 12s. 8d., at $4.8670	$385,941.58						
Less $1 per £1,000	79.30						
Net receipts by above check							$385,862.28

Statement of Receipts and Expenditures on Account of Sale of Blue and White Fox Skins by C. M. Lampson & Co., London, March 18 and 19, 1912.

	£	s.	d.	£	s.	d.	
Certified check, Alfred Fraser, New York, to order of Secretary of Commerce and Labor							$15,096.58
Sale of 371 blue foxes and 20 white foxes	3,412	10	0				
Less 2½ per cent discount	85	6	3				
				3,327	3	9	
Expenses in connection with sale:							
Ocean freight	3	6	5				
New York disbursements	5	11	1				
Marine insurance	15	5	10				
Cleaning 371 blue fox skins, at 4½d.	6	19	1				
Cleaning 20 white fox skins, at 4d.		6	8				
Commission, 6 per cent	199	12	8				
				231	1	9	
Net proceeds				3,096	2	0	15,096.58

OTHER FUR-BEARING ANIMALS.

EXTENSION OF ALASKA FISHERIES SERVICE.

Section 4 of the act approved April 21, 1910, for the protection of the seal fisheries of Alaska, provides also for the protection of the sea otter and all other fur-bearing animals of Alaska, and reads as follows:

No person shall kill any otter, mink, marten, sable, or fur seal, or other fur-bearing animal, within the limits of Alaska Territory or in the waters thereof; and every person guilty thereof shall, for each offense, be fined not less than two hundred nor more than one thousand dollars or imprisoned not more than six months, or both; and all vessels, their tackle, apparel, furniture, and cargo found engaged in violation of this section shall be forfeited; but the Secretary of Commerce and Labor shall have power to authorize the killing of any such mink, marten, sable, fur seal, or other fur-bearing animal under such regulations as he may prescribe; and it shall be the duty of the Secretary of Commerce and Labor to prevent the killing of any fur seal except as authorized by law and to provide for the execution of the provisions of this section until it is otherwise provided by law.

Section 9 of the same act authorizes the Secretary of Commerce and Labor to appoint such additional officers, agents, and employees as may be necessary to carry out the provisions of that act and the laws of the United States relating to the seal fisheries of Alaska.

The sundry civil appropriation bill approved March 4, 1911, provided specifically for the appointment of one warden and four deputy wardens, Alaska Fisheries Service, to enforce the law and regulations for the protection of fur-bearing animals. Under this authority the following appointments were made: Harry J. Christoffers, of Wisconsin, warden; Claude J. Roach, of Michigan; G. Dallas Hanna, of

Kansas; Lee R. Dice, of Washington; and Fred H. Gray, of Alaska, deputy wardens.

In selecting persons to fill these positions the department endeavored to secure men possessing special fitness for the duties which they would be called upon to perform, and among the qualifications that were regarded as important, if not essential, were the following: Strong physique and ability to take care of oneself in the woods and afield; sufficient biological education and training and field experience to enable them to have an intelligent conception of the many biological problems with which they will have to deal, to carry on investigations regarding the habits, abundance, and distribution of the animals with which they will be concerned, and to prepare reports thereon; experience and skill in methods as collectors of mammals and other natural history specimens; real interest in the problems relating to the habits and conservation of fur-bearing animals; and especially intelligence, judgment, tact, and courage in dealing with hunters and trappers and in the enforcement of the law and regulations. They should also possess some knowledge of the fur business and be able to distinguish the different grades of furs.

PROBLEMS OF PROTECTION OF FUR-BEARING ANIMALS.

The proper and efficient regulation of the fur industry and the conservation of the fur-bearing animals require knowledge of the habits of the animals, their food, age of maturity, rate of reproduction, season of birth of the young, ratio of sexes, and family habits; diseases, adaptability to domestication, etc., and particularly the season when the fur is at its best and the effect of certain regulations upon its successful and profitable capture; the present abundance and distribution and probability of extinction or essential impairment in number; and the interrelation of species.

Auxiliary to these main problems is the question of the dependence of the natives upon certain species for food and clothing. Not only are certain animals a prominent, if not principal, element in the domestic necessities of the Indian, but traffic in fur is at times his only resource for the procurement of articles which he has learned from the white man to use and need.

The most immediate question demanding regulation is the taking of unprime furs. This reprehensible practice is perhaps most largely to be attributed to the native. When it is considered how recently ideas of conservation have entered the minds of civilized Americans it can hardly be hoped that the native will at once appreciate the ultimate beneficence of a withdrawal of his license to kill at any and all times when suited to his convenience or when he may do so with the least expenditure of energy.

During the early autumn, before the complete freezing over of the waters or the fall of snow, many species of fur-bearing animals may be taken with ease and in abundance that later either migrate to other sections or house up in dens in such manner as to render their capture impossible or much more difficult. At this season none of the fur is prime, but the conditions for pleasurable pursuit are tempting. The "running" of a 10-mile line of traps in midwinter with the thermometer registering 25° to 50° below zero is not to the taste of a people who regard natural products as a gift of the supernatural for their especial use.

The usual method of preventing the waste incident to killing fur animals when the fur is not prime is the establishment of close seasons. In a region of limited extent and not greatly diversified this is quite effective. Alaska, however, comprises territory of a wide range in latitude and natural conditions.

Many of the species have a very wide range throughout Alaska, and, on account of the very diverse climatic conditions, the fur does not become prime in the fall or unprime in the spring on the same dates throughout all Alaska. For example, the fur of the muskrat in southeast Alaska may become unprime as early as the first or middle of May, while on the Yukon and in the extreme northern portion of its range it may remain prime several weeks longer. The same is probably true of foxes and other species.

And again, it may be found in some cases that proper protection during the breeding season will demand a close season to cover it even if it includes a part of that season in which the fur is prime. To determine the proper time and extent of close seasons which will prove most effective in the protection of fur-bearing animals, consideration must be given to the following requirements: In the first place, the close season must be such as will protect the animals during the entire period when their fur is unprime. It shows poor business sense on the part of the hunter or trapper to kill any animal whose fur is not prime; it is equally poor business sense for traders to buy unprime skins. In the second place, an animal should not be killed when its death would cause the starvation or death of the young which are dependent upon it. This contributes at once to the destruction of the species and, sooner or later, to the financial loss of both the hunter and the trader. In the third place, an animal should not be killed at any time if the species is seriously depleted or in danger of commercial extermination.

Stating the question somewhat differently, the taking of fur-bearing animals should be permitted only (1) when their fur is prime, (2) when their death does not work harm to the young, and (3) when the species is so abundant as to need no prolonged close period.

If a sufficient number of wardens and inspectors could be provided to insure careful inspection of all shipments of furs, the simplest and most effective method of conserving the fur-bearing animals would be to make it illegal to have in possession, sell, purchase, or ship unprime skins of any species.

A regulation of this kind would probably work a hardship in some instances. It sometimes happens that an individual animal may have unprime fur at a time when most of the animals of its species are prime; and the hunter can not tell whether the fur is prime or not until the animal has been captured. And it is sometimes necessary to kill animals for food. It does not seem, however, that these instances are likely to be of such frequent occurrence as to constitute serious or valid objections to such a regulation.

A practice which is largely responsible for the diminution of fur-bearing animals in certain regions is the use of poison. The essential viciousness of this method of capture is apparent at once. One hunter with a minimum of effort may by this means practically exterminate the fur animals of a comparatively wide area. Not only may practically all of the animals of the region be killed but many of them, dying in out-of-the-way places, will not be found by the hunter and will therefore be a clear loss. The use of poison is comparable to the use of dynamite in killing fish, and the practice should meet with the disapproval of all concerned and with every effort toward its discouragement. Druggists and dealers in supplies can give support by care in the sale of poison.

Attention is called, moreover, to the fact that the use of poison at any time to kill any fur-bearing animal is prohibited by order of the Secretary of Commerce and Labor, which order has the force of law. Under the act of April 21, 1910, the penalty for violation of this law is a fine of not less than $200 nor more than $1,000 and imprisonment for not more than six months. Section 55 of the criminal code of Alaska makes it unlawful to administer poison to any animals the property of another, and section 186 makes anyone who aids or abets in the commission of a crime, whether present or not, a principal in that crime. The sale of poison to, or its procurement for, any person known to obtain it for the purpose of killing fur animals or animals the property of another would be in aid of the commission of that crime.

Under the construction of this order the use of poison to kill wolves is unlawful. If it were possible to prevent other animals from reaching the poison set for this purpose a specific exemption in the case of wolves could be recommended. But in actual practice any poison set for wolves would be many times more destructive to other animals than to the wolves, these latter being usually sufficiently wary to escape.

The possibility of determining by an examination of the skin whether the animal from which it was taken was killed by poison is a mooted question. Some dealers in furs claim that the effects of the poison will show in the skin or fur, but no convincing evidence has been presented. Doubtless many of the skins from poisoned animals are inferior, but the cause probably lies in the fact that the animals were not discovered and skinned until considerable time after they died and decomposition had begun. A series of investigations for the purpose of determining the physiological and chemical effects on the skin of poison administered to fur-bearing animals would no doubt answer this question and should be undertaken.

As the scarcity of fur in the regions hitherto producing the supply grows more marked, attention is turned to the possibility of making up for this falling off by the propagation of the more readily domesticated fur bearers. Heretofore the price of the raw pelt has been so small that propagation and feeding has not been profitable except under the most favorable circumstances. An even greater drawback has been the fact that, by the methods pursued, the product secured was less valuable than the pelts of wild animals. At present the most promising branch of fur culture seems to be the rearing of black foxes. The price of these pelts is so high that with a limited output there is still a good profit, and fox farming in Alaska was at one time promoted as a sure source of fortune. The general plan followed was to lease or take possession of some small island, place a few pairs of foxes thereon, usually the blue fox, and let them run at large. The only assistance given by the "farmer" was to supply a scanty diet of fish and put up some shelters. Experience did not confirm the expectations of large returns to be thus obtained, and there are now few fox farms operated. The breeding of foxes on the seal islands is among the more successful efforts.

UNUSUAL MORTALITY AMONG FUR-BEARING ANIMALS.

The periodic occurrence of a plague or disease of some sort causing great mortality among the rabbits or hares of Alaska is a matter of much importance to the fur industry. The hare is an important, if not essential, element of food to certain of the fur animals. There is a general belief that at intervals of about seven years the hares are almost wiped out by the spread of some disease, with the result that those animals dependent upon them for food either starve or migrate. For a number of years succeeding this climax there is again a gradual upbuilding of the number of hares until the normal is reached, to be followed soon by a recurrence of the destruction. With this scarcity of natural food results an increased destruction of each other among the fur animals themselves, decrease in reproduction, and a temporary fur famine in the locality. With the

approaching extinction of the fur-bearing animals from persistent hunting, use of needlessly destructive methods of capture and destruction of the young, the influence of food factors is less noticeable. On the other hand, as proper regulation governing the capture of the flesh-eating fur animals permits their number to increase, knowledge of the vegetable-eating animals that furnish them food will become again of practical importance.

BEARS.

There are three principal groups of bears in Alaska—the polar, the brown, and the black bears. Under the Alaska game law, the brown bear is classed with the game animals and is under the jurisdiction of the Bureau of Biological Survey of the Department of Agriculture. For statistical purposes only, the Department of Commerce and Labor requires statements from the shippers of pelts of these animals.

There is no open season for polar bears and their killing at any time is unlawful. The black bear is regarded as a fur-bearing animal and its killing is permitted, except during the summer when its fur is of little or no value, from June 1 to August 31.

Some criticism has been made of the laws protecting the brown and black bears to the effect that they are destructive to domestic stock, and in the case of the former, a menace to human life. The best evidence obtainable from hunters and those familiar with the habits of bears indicates that they rarely or never attack man until wounded or cornered. They usually make off as rapidly as possible and the hunter finds great difficulty in coming within sight of them.

With regard to the destruction of cattle, it is doubtless true that bears will, when driven by hunger, destroy pigs and other domestic animals. But the limited extent to which the raising of domestic animals is now carried on in sections of Alaska where such damage would interfere with the proper and profitable conduct of the industry reduces such danger to a negligible quantity. The few possible isolated cases of loss have not been shown to justify the destruction of a valuable fur animal and a species of big game which attracts many hunters with the consequent benefit to the territory.

WOLVES.

Wolves may be killed in any season. Placing a bounty upon them would be a salutary measure. The heavy inroads made upon the deer of southeast Alaska by the indiscriminate slaughter a few years ago have apparently so reduced the natural productivity of that animal that it is approaching extinction. Scarcity of natural food for the wolves has forced them more into evidence, and after

loss of the balance normally existing between the various forms of animal life the weaker, such as the deer, must rapidly succumb.

SEA OTTER.

The sea otter is now protected both within territorial limits and on the high seas. The killing of a sea otter on the high seas under any conditions by any subject of the United States, Great Britain, Japan, or Russia, or within territorial waters by any person, is unlawful.

STATISTICS OF FURS SHIPPED FROM ALASKA.

Even approximately complete records of shipments of furs from Alaska have never been kept. The only complete statistics of all shipments are those made from the Pribilof Islands. Approximately complete account has been kept of all shipments that passed through the customhouses, but of the vast quantities of furs that have been sent out of Alaska by mail and the not inconsiderable quantities that have been carried out in personal baggage, the Government has had no record.

When jurisdiction in this matter was transferred to the Department of Commerce and Labor steps were at once taken looking toward the development of a system by means of which complete and trustworthy records might be secured of the shipment of furs from Alaska. An arrangement was made with the Post Office Department whereby any person desiring to ship furs out of Alaska by mail must fill out a blank, supplied for that purpose, stating the place from which shipped, the names and addresses of the consignor and consignee, and the number and value of the various kinds of pelts contained in the package with certificate to the correctness of the statements made by the shipper, after which the blank thus certified is mailed to the Bureau of Fisheries, Washington, D. C.

Similar blanks are required to be filled out for shipments by freight or express or otherwise. While this method of reporting shipments has been in use only for a little more than one year it has proved quite satisfactory and will, it is believed, when perfected, enable the Bureau to secure practically complete records of fur shipments from Alaska.

The results thus far obtained are very interesting and valuable. Not only do these reports supply valuable data regarding the actual and relative abundance of the different species of fur-bearing animals in Alaska, but they also give information concerning the geographic distribution of the species, the shipping points, names of shippers, buyers, and consignees, methods and time of shipment and various other matters of interest.

The following statement in tabular form shows by species the amount and value of furs shipped from Alaska in the calendar year 1911:

SHIPMENT OF FURS FROM ALASKA IN 1911.

Products.	By mail.		Otherwise.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Bear, black	4	$37	613	$5,589	617	$5,626
Bear, black, mounted			1	50	1	50
Bear, brown			23	864	23	864
Bear, cinnamon			9	90	9	90
Bear, glacier			1	10	1	10
Bear, polar			313	4,985	313	4,985
Beaver			118	582	[a] 118	582
Ermine	675	575	3,536	3,047	4,211	3,622
Fox, black			1	293	1	293
Fox, blue	9	250	920	27,785	929	28,035
Fox, blue [b]			371	16,862	371	16,862
Fox, cross	20	171	382	3,288	402	3,459
Fox, red	278	2,105	7,221	46,417	7,499	48,522
Fox, silver			10	1,795	10	1,795
Fox, silver gray	8	1,350	64	6,243	72	7,593
Fox, white	461	4,974	7,602	46,738	8,063	51,712
Fox, white [b]			20	200	20	200
Hares, Arctic	32	15	29	19	61	34
Lynx	86	2,750	1,122	20,851	1,208	23,601
Marten	300	3,235	5,855	50,274	6,155	53,509
Mink	1,444	5,371	20,151	72,346	21,595	77,717
Muskrat	2,457	1,228	79,366	16,675	81,823	17,903
Otter, land	60	597	1,064	10,025	1,124	10,622
Otter, sea			23	10,600	23	10,600
Otter pups, sea			1	20	1	20
Seal, fur			12,145	432,231	12,145	432,231
Squirrel	88	17	203	21	291	38
Weasel	113	59	586	420	699	479
Wolf	4	18	73	487	77	505
Wolverine	5	21	174	1,170	179	1,191
Total	6,044	22,773	141,997	779,977	148,041	802,750

[a] Includes 18½ ounces of beaver castors, valued at $6.
[b] Shipped from Pribilof Islands.

PERMITS TO CAPTURE AND SHIP FUR-BEARING ANIMALS FOR BREEDING OR OTHER PURPOSES.

Under the provisions of section 4 of the act approved April 21, 1910, the Secretary of Commerce and Labor issued, in the calendar year 1911, six permits to capture fur-bearing animals for special purposes. In the majority of cases the animals were desired for propagation purposes. A few permits were issued to collect fur-bearing animals for museums and zoological parks.

The capture of any fur-bearing animal out of season or the shipping of any such live animal out of Alaska, unless specifically authorized by the Department, is unlawful. Anyone desiring to capture and retain or ship for breeding purposes, or for museums or zoological parks, any fur-bearing animal, should apply to the Secretary of Commerce and Labor, Washington, D. C., for a permit authorizing him to do so.

STATISTICS OF THE FISHERIES OF ALASKA FOR 1911.

By F. M. Chamberlain, *Agent, Alaska Salmon Fisheries,*
and
John N. Cobb, *Assistant Agent.*

SUMMARIZED STATISTICS.

As in the similar reports for previous years, the District of Alaska is here considered in the four geographic sections generally recognized, as follows: Southeast Alaska, embracing all that narrow strip of mainland and the numerous islands adjacent, from Portland Canal northwestward to and including Yakutat Bay; central Alaska, the region on the Pacific, or south side, from Yakutat Bay westward, including the Aleutian chain; western Alaska, the shores of Bering Sea and islands in this sea; and arctic Alaska, from Bering Strait to the Canadian border.

The Bureau has been unable to secure even approximately complete data as to the persons engaged or the investment in the hunting of aquatic animals, except fur seals and sea otters. This industry is largely in the hands of the natives throughout the district or carried on by whites during seasons when other employment is not available.

PERSONS ENGAGED.

The number of persons engaged in the fisheries of Alaska in 1911 was 17,932, an increase of 2,312 over the number so engaged in 1910. Of these, 7,619 were whites, 4,642 Indians, 2,553 Japanese, 2,466 Chinese, 2 Hawaiians, and 650 miscellaneous (these include Filipinos, Porto Ricans, Mexicans, etc.), as compared with 6,836 whites, 4,147 Indians, 2,206 Japanese, 2,411 Chinese, 4 Koreans, and 16 Filipinos in 1910, showing an increase in 1911 of 783 whites, 495 Indians, 347 Japanese, and 55 Chinese. The fact that the fishermen serve as sailors on the transporting vessels to and from the salmon canneries and salteries explains the small number of transporters shown in the table as compared with the large number of transporting vessels.

PERSONS ENGAGED IN THE ALASKA FISHERIES IN 1911.

Occupation and race.	Southeast Alaska.	Central Alaska.	Western Alaska.	Arctic Alaska.	Total.
Fishermen:					
Whites	1,514	913	1,830	10	4,267
Indians	1,841	280	127	430	2,678
Japanese	43				43
Chinese	2				2
Hawaiians	2				2
Total	3,402	1,193	1,957	440	6,992
Shoresmen:					
Whites	1,056	416	1,298		2,770
Indians	1,439	234	267		1,940
Japanese	709	407	1,391		2,507
Chinese	822	491	1,151		2,464
Miscellaneous	25	20	605		650
Total	4,051	1,568	4,712		10,331
Transporters:					
Whites	303	143	136		582
Indians	17	7			24
Japanese	1	2			3
Total	321	152	136		609
Grand total:					
Whites	2,873	1,472	3,264	10	7,619
Indians	3,297	521	394	430	4,642
Japanese	753	409	1,391		2,553
Chinese	824	491	1,151		2,466
Hawaiians	2				2
Miscellaneous	25	20	605		650
Total	7,774	2,913	6,805	440	17,932

INVESTMENT.

The total investment in the fisheries of Alaska, exclusive of that in the vessel fisheries for offshore cod and halibut, is $22,671,387, an increase of $1,959,965, as compared with 1910. Of this amount $19,931,215 is invested in the salmon canning business, and $623,126 in salting and mild curing salmon; $1,194,073 in the halibut fishery; $295,220 in the herring fishery, and $215,670 in the central Alaska cod fishery. It is thus seen that over 90 per cent of the capital engaged in the inshore fisheries in the Territory is employed in the various branches of salmon packing. The investment in salmon canning in 1911 exceeds that of 1910 by $1,590,466; this is attributable largely to the 13 new plants established in 1911. The quantity of apparatus used increased quite materially, also due largely to the increase in the number of plants operating.

INVESTMENT IN THE ALASKA FISHERIES IN 1911.

Items.	Southeast Alaska.		Central Alaska.		Western Alaska.		Arctic Alaska.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.	Number.	Value.	Number.	Value.
Fishing vessels:										
Steamers and launches	98	$687,530	2	$10,620					100	$698,150
Tonnage	1,467		48						1,515	
Outfit		259,346		1,200						260,546
Sailing	2	12,500	2	4,360					4	16,860
Tonnage	286		87						373	
Outfit		300		1,300						1,600
Transporting vessels:										
Steamers and launches	84	503,565	39	322,028	46	$644,433			169	1,470,026
Tonnage	1,748		1,791		4,079				7,618	
Outfit		161,550		89,800		105,800				357,150
Sailing	9	238,000	17	443,251	37	841,222			63	1,522,473
Tonnage	10,151		20,684		46,719				77,554	
Outfit		15,500		25,100		53,900				94,500
Steamers and launches (under 5 tons)	194	335,625	13	15,294	10	23,979			217	a 374,898
Boats, sail and row	1,111	64,755	595	37,820	997	199,759	73	$10,950	2,776	313,284
Scows and lighters	216	110,070	134	65,356	148	125,829			498	301,255
Pile drivers	25	64,573	24	45,919	18	38,300			67	148,792
Apparatus, vessel fisheries:										
Purse seines	4	3,000	2	214					b 6	3,214
Lines, hand		300								300
Lines, trawl		22,370		307						22,677
Shotguns			48	576					48	576
Whaling gear		1,015								1,015
Apparatus, shore fisheries:										
Haul seines	66	15,262	48	16,937	2	125			c 116	32,324
Purse seines	199	78,636	5	3,015					d 204	81,651
Gill nets	659	77,358	174	19,813	1,131	105,694			e 1,964	202,865
Dip nets	13	123	20	10					33	133
Lines, hand		422		1,615						2,037
Lines, trawl		10,441								10,441
Traps, stake	76	207,411	46	103,080	14	20,692			136	331,183
Traps, floating	19	34,342	2	10,500					21	44,842
Pots, crab	420	1,230							420	1,230
Hooks, crab	10	5							10	5
Spears or gaffs	70	31							70	31
Hoes	14	10	8	6					22	16
Shotguns	40	1,200							40	1,200
Whaling gear								16,425		16,425
Cash capital		4,253,832		1,636,338		2,897,495		8,000		8,795,665
Shore and accessory property		2,966,361		1,511,009		3,082,153		4,500		7,564,023
Total		10,126,663		4,365,468		8,139,381		39,875		22,671,387

a Includes outfit.
b Aggregate length of 1,350 yards.
c Aggregate length of 40,228 yards.
d Aggregate length of 73,702 yards.
e Aggregate length of 283,123 yards.

PRODUCTS.

A change has been made this year in the manner of tabulating the products of the fisheries. As the packing establishments generally import their fishermen from outside the district and furnish them with boats, gear, etc., it has been found practically impossible to arrive at the value of the products as they leave the fishermen's hands; hence heretofore the values shown have been for the prepared products only, while the weights given represented the round weights (or weight of the fish as taken from the water) of the fish used in preparing the products. In the present report two tables have been

prepared, one showing the estimated round weights of the different species of fish used in preparing finished products, the other showing the weights of all prepared products packed for market and their selling value.

This year 256,154,109 pounds of fish were used in preparing the various fish products. Salmon is the most important, with a total for all species of 207,636,174 pounds; halibut, herring, and cod are next in order of quantity produced.

CATCH OF THE ALASKA FISHERIES IN 1911, SHOWN BY SPECIES AND WITH ESTIMATED ROUND WEIGHTS.[a]

Species.	Southeast Alaska.	Central Alaska.	Western Alaska.	Total.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Black cod	125,092			125,092
Cod	6,250	4,793,651		4,799,901
Eulachon	46,869			46,869
Flounders	5,000			5,000
Halibut	21,779,949	114,305		21,894,254
Herring	20,942,172	215,000		21,157,172
Pollock		2,650		2,650
Redfish, or Sitka "black bass"	20,000	10,000		30,000
Rock cod	44,135	15,000		59,135
Salmon:				
Coho, or silver	7,486,019	1,427,608	1,089,340	10,002,967
Dog, or chum	20,265,314	636,000	1,909,770	22,811,084
Humpback, or pink	69,143,581	1,755,420	470,540	71,369,541
King, or spring	5,943,772	1,178,070	2,128,050	9,249,892
Red, or sockeye	15,395,990	30,769,220	48,037,480	94,202,690
Shark and dogfish livers	261,968			261,968
Smelt	5,000			5,000
Tomcod	937			937
Trout:				
Cutthroat	1,000			1,000
Dolly Varden, or salmon trout	62,783	20,445		83,228
Rainbow	8,750			8,750
Steelhead	35,195	1,784		36,979
Total	161,579,776	40,939,153	53,635,180	256,154,109

[a] For obvious reasons crustaceans, mollusks, mammals, and seaweed have not been included in this table but are shown in the next table.

The total weight of the prepared products amounted to 177,572,873 pounds, which sold for $16,863,728. Under appropriate headings elsewhere in this report will be found detail tables showing the various ways in which these products were packed. Of the total value $16,281,055 is fish products alone. Under the general heading are included $100,084 worth of whale oil and whalebone, $1,105 of walrus ivory, $8,638 of crustaceans and shellfish, $200 of seaweed, and $472,646 aquatic furs. The total value of the furs produced in Alaska is shown in another table.

PRODUCTS OF THE ALASKA FISHERIES IN 1911.

Products.	Southeast Alaska.		Central Alaska.		Western Alaska.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black cod:						
Fresh	33,450	$1,309				
Pickled	62,460	2,309				
Cod:						
Fresh	5,000	250	20,000	$800		
Pickled			900	48		
Dry-salted			3,575,588	107,862		
Tongues, pickled			800	80		
Eulachon:						
Fresh	4,135	169				
Pickled	30,075	909				
Smoked	1,000	60				
Flounders	4,000	120				
Halibut:						
Fresh	14,251,677	702,011	60,000	2,400		
Frozen	2,896,995	113,646	29,479	884		
Fletched	69,276	2,785				
Pickled	400	24				
Canned	7,344	612				
Fins, pickled	400	8				
Herring:						
Fresh	1,158,495	8,250	12,000	360		
Frozen	750,146	4,500				
Pickled	1,196,100	30,396	150,000	4,500		
Dry-salted	2,027,770	16,603				
Eggs, dried	12,000	600				
Pollock			2,100	105		
Redfish, or Sitka black bass	16,000	800	8,000	400		
Rock cod:						
Fresh	35,100	1,252	12,000	480		
Pickled	200	10				
Salmon:						
Fresh—						
Coho, or silver	41,400	872	8,000	240		
Dog, or chum	2,400	24				
Humpback, or pink	32,000	400				
King, or spring	1,748,212	103,504	5,000	200		
Red, or sockeye	58,560	2,758	30,000	900		
Frozen—						
Coho, or silver	264,352	10,574	48,546	1,942		
Dog, or chum	33,708	674				
Humpback, or pink	5,956	119				
King, red-meated	59,766	4,184				
King, white-meated	14,459	434				
Red, or sockeye	3,225	97				
Canned—						
Coho, or silver	4,780,176	573,163	900,432	107,278	746,976	$82,206
Dog, or chum	13,802,784	1,059,326	435,744	34,470	1,303,632	105,767
Humpback, or pink	46,727,712	3,846,002	1,202,976	99,816	322,656	26,888
King, or spring	67,440	8,494	767,424	105,628	1,350,000	180,966
Red, or sockeye	10,503,552	1,416,241	20,681,088	2,743,740	31,950,624	4,203,252
Mild-cured—						
Coho, or silver	49,228	2,464				
King, or spring	2,502,395	280,697	36,000	2,880		
Pickled—						
Coho, or silver	31,600	1,499	13,000	650		
Dog, or chum	19,800	418	400	14	6,400	234
Humpback, or pink	223,600	11,214	800	24		
Humpback backs	30,000	600				
King, or spring	1,400	50	600	35	118,000	8,010
King heads	200	15				
Red, or sockeye	600	45	210,000	13,106	1,037,200	66,427
Red tips					3,000	136
Dry-salted—						
Dog, or chum	33,285	1,340			28	3
Humpback, or pink, backs	80,000	800				
Smoked—						
Coho, or silver, backs			1,800	180		
Dog, or chum	3,787	75				
Humpback, or pink	5,000	100				
Red, or sockeye, backs			14,200	1,420		
Salmon bellies, pickled:						
Coho, or silver	200	17	7,400	472		
Dog, or chum	1,400	77				
Humpback, or pink	135,200	5,122				
King, or spring	400	30				
Red, or sockeye			108,600	9,103	14,200	740
Smelt	4,000	200				

PRODUCTS OF THE ALASKA FISHERIES IN 1911—Continued.

Products.	Southeast Alaska.		Central Alaska.		Western Alaska.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Tomcod	750	$30				
Trout:						
Cutthroat	800	40				
Dolly Varden, or salmon trout—						
Fresh	49,000	2,000	23,000	$1,150		
Frozen			1,271	65		
Pickled	1,150	66				
Rainbow	7,000	280				
Steelhead—						
Fresh	6,000	240				
Frozen	20,921	1,883	222	12		
Pickled			300	15		
Canned	480	58	816	99		
Fertilizer:						
Herring	3,520,000	61,600				
Oil:						
Herring	2,572,500	75,460				
Dogfish and shark	139,125	5,159				
Whale	1,856,250	86,625	20,250	945		
Clams	7,200	450	4,000	150		
Crabs	115,320	5,337	49,500	2,700		
Seaweed	4,000	200				
Shrimp	10	1				
Aquatic furs and skins:						
Beaver	28	130	68	340	22	$112
Castoreum					1	6
Muskrat	62	128	171	444	9,995	17,331
Otter—						
Land	485	2,038	1,010	4,001	1,315	4,583
Sea			118	10,620		
Seal -						
Fur	240	1,080			72,630	431,151
Hair	2,445	670			66	12
Walrus ivory					400	410
Whalebone	55,000	5,500				
Total	112,188,586	8,467,227	28,443,603	3,260,558	36,937,145	5,128,234

Products.	Arctic Alaska.		Total.	
	Pounds.	Value.	Pounds.	Value.
Black cod:				
Fresh			33,450	$1,309
Pickled			62,460	2,309
Cod:				
Fresh			25,000	1,050
Pickled			900	48
Dry-salted			3,575,588	107,862
Tongues, pickled			800	80
Eulachon:				
Fresh			4,135	169
Pickled			30,075	909
Smoked			1,000	60
Flounders, or sole			4,000	120
Halibut:				
Fresh			14,311,677	704,411
Frozen			2,926,474	114,530
Fletched			69,276	2,785
Pickled			400	24
Canned			7,344	612
Fins, pickled			400	8
Herring:				
Fresh			1,170,495	8,610
Frozen			750,146	4,500
Pickled			1,346,100	34,896
Dry-salted			2,027,770	16,603
Eggs, dried			12,000	600
Pollock			2,100	105
Redfish, or Sitka black bass			24,000	1,200
Rock cod:				
Fresh			47,100	1,732
Pickled			200	10

Reports of the Alaska Fisheries in 1911—Continued.

Products.	Arctic Alaska.		Total.	
	Pounds.	Value.	Pounds.	Value.
Salmon:				
Fresh—				
Coho, or silver			49,400	$1,112
Dog, or chum			2,400	24
Humpback, or pink			32,000	400
King, or spring			1,753,212	103,704
Red, or sockeye			88,560	3,658
Frozen—				
Coho, or silver			312,898	12,516
Dog, or chum			33,708	674
Humpback, or pink			5,956	119
King, red-meated			59,766	4,184
King, white-meated			14,459	434
Red, or sockeye			3,225	97
Canned—				
Coho, or silver			6,427,584	762,647
Dog, or chum			15,542,160	1,199,563
Humpback, or pink			48,253,344	3,972,706
King, or spring			2,184,864	295,088
Red, or sockeye			63,135,264	8,363,233
Mild-cured—				
Coho, or silver			49,228	2,464
King, or spring			2,538,395	283,577
Pickled—				
Coho, or silver			44,600	2,149
Dog, or chum			26,600	666
Humpback, or pink			224,400	11,238
Humpback backs			30,000	600
King, or spring			120,000	8,095
King heads			200	15
Red, or sockeye			1,247,800	79,578
Red tips			3,000	136
Dry-salted—				
Dog, or chum			33,313	1,343
Humpback, or pink, backs			80,000	800
Smoked—				
Coho, or silver, backs			1,800	180
Dog, or chum			3,787	75
Humpback, or pink			5,000	100
Red, or sockeye, backs			14,200	1,420
Salmon bellies, pickled:				
Coho, or silver			7,600	489
Dog, or chum			1,400	77
Humpback, or pink			135,200	5,122
King, or spring			400	30
Red, or sockeye			122,800	9,843
Smelt			4,000	200
Tomcod			750	30
Trout:				
Cutthroat			800	40
Dolly Varden, or salmon trout—				
Fresh			72,000	3,150
Frozen			1,271	65
Pickled			1,150	66
Rainbow			7,000	280
Steelhead—				
Fresh			6,000	240
Frozen			21,143	1,895
Pickled			300	15
Canned			1,296	157
Fertilizer:				
Herring			3,520,000	61,600
Oil:				
Herring			a 2,572,500	75,460
Dogfish and shark			b 139,125	5,159
Whale			c 1,876,500	87,570
Clams			d 11,200	600
Crabs			e 164,820	8,037
Seaweed			4,000	200
Shrimp			10	1
Aquatic furs and skins:				
Beaver			f 118	582
Castoreum			1	6

a Represents 343,000 gallons.
b Represents 18,550 gallons.
c Represents 250,200 gallons.
d Represents 1,400 bushels.
e Represents 75,660 crabs.
f Represents 118 skins.

REPORTS OF THE ALASKA FISHERIES IN 1911—Continued.

Products.	Arctic Alaska.		Total.	
	Pounds.	Value.	Pounds.	Value.
Aquatic furs and skins—Continued.				
Muskrat			[a] 10,228	$17,903
Otter—				
Land			[b] 2,810	10,622
Sea			[c] 118	10,620
Seal				
Fur			[d] 72,870	432,231
Hair			[e] 2,511	682
Walrus ivory	772	$695	1,172	1,105
Whalebone	2,767	7,014	57,767	12,514
Total	3,539	7,709	177,572,873	16,863,728

[a] Represents 81,823 skins.
[b] Represents 1,124 skins.
[c] Represents 24 skins.
[d] Represents 12,145 skins.
[e] Represents 837 skins.

SALMON INDUSTRY.

The season of 1911 was an excessively dry one, a condition which the fishermen generally regard as favorable for them. It did not prove so in western Alaska, however, as the catch of salmon in Bristol Bay was quite light.

In southeast Alaska, south of Wrangell Narrows, the run of humpback and dog salmon was very heavy and much more than made up the shortage in western Alaska. This appearance of an extraordinary run is doubtless accentuated by the high percentage that was caught. During a dry season, in consequence of low water in the streams, the salmon do not make the ascent at once, but play about the mouth of the stream for a varying time, thus permitting a very effective use of purse seines and small gear operated in the vicinity of stream mouths. It may well be deduced, however, from the fact of the traps showing correspondingly large catches of humpbacks, that the main reason for the increased number of this species taken lies in the size of the run itself.

CATCH AND THE APPARATUS USED.

Following is a table giving the number of salmon caught in 1911, by apparatus and species, and by species alone, for each geographic section. In southeast Alaska there was a very large increase over the 1910 catch; in central Alaska a small increase; and in western Alaska a considerable decrease. In 1910 the total catch was 33,679,254 fish, while in 1911 it amounted to 43,975,873 fish, an increase of 10,296,619. In all species, except red salmon, there were increases over 1910, the catch of humpback salmon more than doubling.

The different application of gear to the different species is an interesting feature of this table. Of the two principal species, reds and pinks, it will be noted that of reds 54 per cent were taken in gill nets, 25 per cent by seines, and only about 20 per cent in traps. These figures are due to the great preponderance of gill netting for reds in the Bristol Bay region, where practically one-half the total catch is made. On the other hand, over 60 per cent of the catch of pinks was made by seines in southeast Alaska, in which section over 97 per cent of the total catch of this species was made. Only 1½ per cent were taken in gill nets, the mesh not being gauged for such small fish; 35 per cent were taken in traps.

CATCH OF SALMON IN 1911, BY SPECIES AND APPARATUS, FOR EACH GEOGRAPHIC SECTION OF ALASKA.

Apparatus and species.	Southeast Alaska.	Central Alaska.	Western Alaska.	Total.
Seines:				
Coho, or silver	420,515	56,628		477,143
Dog, or chum	1,826,315	84,438		1,910,753
Humpback, or pink	13,463,726	248,230		13,711,956
King, or spring	396	689		1,085
Red, or sockeye	1,438,917	2,948,126	9,252	4,396,295
Total	17,149,869	3,338,111	9,252	20,497,232
Gill nets:				
Coho, or silver	170,619	37,697	121,971	330,287
Dog, or chum	155,749	78	174,043	329,870
Humpback, or pink	230,093	254	91,764	322,111
King, or spring	81,797	23,634	109,722	215,153
Red, or sockeye	394,428	520,803	8,635,162	9,550,393
Total	1,032,686	582,466	9,132,662	10,747,814
Traps:				
Coho, or silver	276,206	89,633	8,000	373,839
Dog, or chum	734,827	20,476	173,823	929,126
Humpback, or pink	7,373,011	259,072		7,632,083
King, or spring	18,418	34,017	3,541	55,976
Red, or sockeye	938,674	2,237,586	299,552	3,475,812
Total	9,341,136	2,640,784	484,916	12,466,836
Lines:				
Coho, or silver	37,068			37,068
King, or spring	174,441			174,441
Total	211,509			211,509
Spears or gaffs:				
Coho, or silver	3,010			3,010
Red, or sockeye	49,472			49,472
Total	52,482			52,482
Total:				
Coho, or silver	907,418	183,958	129,971	1,221,347
Dog, or chum	2,716,891	104,992	347,866	3,169,749
Humpback, or pink	21,066,830	507,556	91,764	21,666,150
King, or spring	275,052	58,340	113,263	446,655
Red, or sockeye	2,821,491	5,706,515	8,943,966	17,471,972
Grand total	27,787,682	6,561,361	9,626,830	43,975,873

CANNING.

CONDITIONS AND EVENTS OF THE SEASON.

The season of 1911 has the distinction of having been the most profitable the salmon packers of Alaska ever experienced. At the opening of the season there were no stocks in first hands, while the demand for the new pack was so great that the packers could have easily contracted in advance for the sale of the total pack for which their plants were outfitted. Many of them held off, however, preferring to take their chances on the opening prices, and their judgment was vindicated, as these were considerably above most of the contract prices offered, and in some instances better than the opening prices.

As the season of 1910 had been a profitable one, the attention of capital was attracted to Alaska with the result that 9 new canneries were built and operated this year in southeast Alaska, 2 in central Alaska, and 2 in western Alaska, a total increase of 13 in all the district. In central Alaska the Alaska Packers Association, which had been operating 2 canneries at Karluk, abandoned these and occupied a new single cannery of equivalent capacity on Larsen Bay. The names of the new companies appear in the list of canneries.

On October 29 the cannery of the Kasaan Co., at Kasaan, Prince of Wales Island, southeast Alaska, was burned, the cannery and warehouses and a considerable part of the season's pack being totally destroyed. This is the third time this plant has been destroyed by fire, the first time being in 1906 and the second in 1910. The plant had been rebuilt and operated in 1911, and the company intends to again rebuild in time to operate in the season of 1912.

On August 29 a part of the piling under the cannery of F. C. Barnes Co., at Lake Bay, southeast Alaska, collapsed and a portion of the season's pack slid into the water. The greater part was rescued, but the plant had been so badly damaged that canning operations were suspended for the remainder of the season.

During a heavy gale on September 17 the piling under the warehouse of the Fidalgo Island Packing Co., at Ketchikan, southeast Alaska, gave way and precipitated into the water nearly all of the season's pack. The greater part was subsequently recovered, but many cans were dented and broken and a further loss was occasioned by the rusting of the cans from their contact with salt water, so that most of the pack had to be sold much below the prevailing market prices.

In April, during a storm, the ship *Jabez Howes*, laden with the season's outfit for the Chignik canners of the Columbia River Packers' Association, was driven ashore on the beach near the entrance to Chignik Bay. The outfit was saved, but the vessel became a total loss. During the same storm the ships of the Chignik canneries of the Alaska

Packers' Association and the Northwestern Fisheries Co. also were driven ashore, but later on were hauled off without material damage to either vessels or cargoes.

On September 10 the Pacific Steamship Co.'s steamer *Ramona,* plying between Seattle, Wash., and southeast Alaska points, was wrecked on Spanish Islands in southeast Alaska and became a total loss. In addition to other goods she had aboard 11,177 cases of salmon from the Funter Bay and Hawk Inlet canneries. The greater part of the salmon cargo floated ashore in the vicinity of the wreck and a considerable quantity was picked up by power boats and sold to near-by canneries at prices ranging from 50 cents to $2.50 per case. The latter cleaned, relacquered, and relabeled the cans and sold them as part of their own packs.

As all of the salmon lost in these various disasters had passed through all the stages of packing and was eventually paid for by the insurance companies, it has been included in the statistical tables.

An innovation in the salmon-canning industry this season was the operation of a cannery aboard a ship. Early in the year the Alaska Fish Co. (a new corporation) purchased the old ship *Glory of the Seas.* This vessel has three decks, a net tonnage of 1,939 tons, a length of 240.2 feet, a breadth of 44.1 feet, and a depth of 20 feet. Quarters for the crew were built over the cabins on the quarter deck, the latter being reserved for the officials of the company. The remainder of the upper deck was used for receiving, dressing, and cleaning the fish, which were brought on board by means of a portable elevator attached to the side of the ship. The "iron chink" and the sliming and cleaning tanks were on this deck. The fish were carried in chutes to the second deck, where a line of sanitary machinery had been installed. The retorts were placed on the forward part of the second deck. The third deck was used for cooling and storing the pack. No lacquering or labeling was carried on aboard the ship. This work was done in Seattle.

During the first half of the season the ship was anchored in Hawk Inlet, a bay on the western side of Admiralty Island, in southeast Alaska. When the catch began to drop off here the vessel was towed to Ketchikan, where it remained throughout the remainder of the season.

On the whole, the experiment proved very successful, the only difficulty experienced being to secure a sufficient quantity of fresh water when the vessel was anchored in the large bays.

The use of the new so-called solderless or sanitary cans was quite extensive this season, a few plants being fitted exclusively for this style of pack. Some trouble and loss was occasioned through leaks, due, it is believed, almost wholly to inexperience or to the desire of the packer to increase his output by rushing the cans through the

exhauster too rapidly. Where properly handled this can proved very satisfactory. It is because of the claim that the very small amount of solder used in this style of can frees the contents from danger of lead contamination that the name "sanitary" is applied.

The last 10 years have witnessed many changes in canning methods. A number of new and improved forms of cleaning and packing machines have been installed, and while the main objects sought in their introduction have been the increasing of the output and the elimination of workers they have incidentally improved the pack from a sanitary point of view by cutting down the number of people who have to handle the fish. The use of the sanitary can has aided very materially, but there are still some points which can be very greatly improved.

The machinery in use is well suited for filling 1-pound tall cans, which form the bulk of the pack, but it is not yet adapted to filling the flat cans, and these are still packed by hand. The pack of flat cans in Alaska is very small, usually of the choicest grades only. By means of the neater appearance of the meat when the can is opened, the flat can commands a higher price than the 1-pound tall can. Indian women and children are usually employed to fill the flat cans.

Too little effort is made by the average cannery men to see that cleanliness is observed by their employees, and in very few instances are lavatories for their use to be found. A few of the workers use gloves when packing in order to protect their hands from being cut by the tin, but these are rarely if ever washed. The cannery men should supply gloves to the workers who handle the fish, and should see that these gloves are thrown away at the end of each day's work. Gloves suitable for this work can be purchased in large quantities for a few cents each. With the minimizing of handling in the butchering shed due to the introduction of the iron chink, contact of the dressed fish with the hands of the workmen is now limited to the operations of cutting and filling. By care in the selection of cleanly, healthy laborers for this portion of the work and by furnishing them with better facilities and opportunity to keep clean, the packers will be able to remove the last ground for scruples against a factory-packed product. Water is abundant in Alaska, and it would require slight expenditure only to install proper lavatories in each cannery.

CANNERIES IN OPERATION.

Following is a list of the canneries operated during the season of 1911:

Name.	Location.
Southeast Alaska:	
Tee Harbor Packing Co. (new)	Tee Harbor.
North Pacific Trading & Packing Co	Klawak.
Hidden Inlet Canning Co. (new)	Hidden Inlet.
Astoria & Puget Sound Canning Co	Excursion Inlet.
Thlinket Packing Co	Funter Bay.
Pacific American Fisheries	Excursion Inlet.
George T. Myers & Co	Sitkoh Bay.
Hawk Fish Co. (new)	Hawk Inlet.
Yakutat & Southern Railway Co	Yakutat.
Taku Canning & Cold Storage Co. (formerly John L. Carlson & Co.)	Taku Harbor.
Fidalgo Island Packing Co	Ketchikan.
The Kasaan Co	Kasaan.
Shakan Salmon Co	Shakan.
F. C. Barnes Co	Lake Bay.
St. Elias Packing Co	Dry Bay.
Pillar Bay Packing Co	Pillar Bay.
Metlakahtla Industrial Co	Metlakahtla.
Pacific Coast & Norway Packing Co	Petersburg.
Alaska Pacific Fisheries (formerly C. A. Burckhardt & Co.)	Chomley (new), Yes Bay, and Chilkoot.
Lindenberger Packing Co. (new)	Roe Point.
Deep Sea Salmon Co. (new)	Ford Arm.
Alaska Fish Co. (new)	Floating cannery, Glory of the Seas.
L. Gustave & Co. (new)	Skowl Arm.
M. E. Lane (new)	Myers Chuck.
Alaska Packers Association	Loring and Wrangell.
Northwestern Fisheries Co	Hunter Bay, Quadra, Santa Ana, and Dundas Bay.
Central Alaska:	
Northwestern Fisheries Co	Orca, Kenai, Uyak, and Chignik.
Alaska Packers Association	Kasilof, Larsen Bay, Alitak, and Chignik.
Seldovia Salmon Co. (new)	Seldovia.
Pacific American Fisheries (new)	King Cove.
Columbia River Packers Association	Chignik.
Western Alaska:	
Bristol Bay Packing Co	Kvichak Bay.
Naknek Packing Co	Naknek River.
North Alaska Salmon Co	Ugaguk River, Lockanok, Kvichak Bay, and Nushagak Bay.
Northwestern Fisheries Co	Nushagak Bay.
Alaska-Portland Packers Association	Do.
Alaska Salmon Co	Do.
Columbia River Packers Association	Do.
Alaska Fishermen's Packing Co	Nushagak Bay and Kvichak Bay (new).
Red Salmon Canning Co	Ugashik River.
Alaska Packers Association	Nushagak Bay (2), Kvichak Bay (2), Naknek River (3), and Ugaguk River.

STATISTICS OF THE CANNING INDUSTRY.

Persons engaged. The fishermen engaged this year numbered 4,395, of whom more than one-half were white. The shoresmen, nearly all of whom are employed in the canneries, numbered 9,948. All nationalities show increases as compared with 1910. The transporters numbered 443, a decrease as compared with 1910. In all, 14,786 persons were employed, an increase of 2,355 over 1910. This is an increase of nearly 19 per cent over the previous year, while the increase in investment is less than 8 per cent. This variance may in part be accounted for by the additional help needed in the installation of the new plants, but is perhaps more largely due to the increased number of employees required to handle the heavy run of fish. It will be noted by comparison with the report for 1910 that the increase is mainly in shoresmen, about two-thirds of the total increase appearing in that class.

Another significant item is the increase in the number of Japanese in southeast Alaska, nearly one-half more than 1910, while there was almost no increase of this race in the other sections. Nearly 40 per cent of the total number of persons engaged in the industry in 1911 are whites, while only about 22½ per cent are Indians, the same percentages as in 1910. About one-third of the total number of fishermen employed are Indians. In southeast Alaska over 70 per cent of the fishermen are Indians; in western Alaska almost no Indians are so employed. This is due partly to the peculiar conditions in western Alaska and partly to the nature of the natives. In southeast Alaska the employers are in touch with the sources of the labor market and a defection of their fishing gangs would not ruin the season's work. In western Alaska the industry is dependent upon reliable and responsible labor to furnish the raw material for the cannery. Unfortunately the western native does not yet rank in this class, and the canner is dependent almost wholly upon his imported labor. As the native becomes more responsible and learns the nature of contract he will find more ready employment in the canneries. The employers of labor would be only too ready to be relieved of the expense of transporting help to and from the place of employment and to be able to take on or lay off their workmen to meet the exigencies of the varying abundance of fish.

PERSONS ENGAGED IN THE SALMON-CANNING INDUSTRY IN 1911.

Occupation and race.	Southeast Alaska.	Central Alaska.	Western Alaska.	Total.
Fishermen:				
Whites	493	638	1,801	2,932
Indians	1,280	125	39	1,444
Japanese	17			17
Hawaiians	2			2
Total	1,792	763	1,840	4,395
Shoresmen:				
Whites	874	378	1,244	2,496
Indians	1,380	218	245	1,843
Chinese	822	490	1,147	2,459
Japanese	702	407	1,391	2,500
Miscellaneous[a]	25	20	605	650
Total	3,803	1,513	4,632	9,948
Transporters:				
Whites	228	75	123	426
Indians	14			14
Japanese	1	2		3
Total	243	77	123	443
Grand total:				
Whites	1,595	1,091	3,168	5,854
Indians	2,674	343	284	3,301
Chinese	822	490	1,147	2,459
Japanese	720	409	1,391	2,520
Hawaiians	2			2
Miscellaneous	25	20	605	650
Total	5,838	2,353	6,595	14,786

[a] Includes Mexicans, Filipinos, Porto Ricans, etc.

Investment, wages, etc.—There were 64 canneries in operation—32 in southeast Alaska, an increase of 9 over 1910; 11 in central Alaska, an apparent increase of 1 over 1910, but an actual increase of 2, as the Alaska Packers Association cannery at Larsen Bay does the work which had previously been done by the 2 canneries at Karluk, which have been abandoned; and 21 in western Alaska, an increase of 2 over 1910; a total increase for all Alaska of 12.

There were 154 steamers and launches over 5 tons, 63 under 5 tons, and 50 sailing vessels engaged in transporting supplies and the pack and doing general work for the canneries. This is a decrease in the number of vessels, but an increase in their size and value.

All forms of apparatus, except haul seines and spears or gaffs, show increases over 1910. The increases are especially noticeable in purse seines, gill nets, and traps. The number of traps in southeast Alaska was almost doubled. In the case of the other apparatus it will be noted that while the number of haul seines fell from 104 to 86 the yardage decreased only 1,532 yards. In the case of the purse seines the increase in yardage is not quite so great as the increase in number, indicating the use of a slightly shorter seine on the average.

INVESTMENT, ETC., IN THE SALMON-CANNING INDUSTRY IN 1911.

Items.	Southeast Alaska.		Central Alaska.		Western Alaska.		Total.	
	Number.	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
Canneries	32	....	11	....	21	....	64	....
Transporting vessels:								
Steamers and launches over 5 tons	78	$450,365	33	$280,741	43	$600,433	154	$1,331,539
Tonnage	1,608	....	1,278	....	3,922	....	6,808	....
Outfit	....	149,000	....	83,500	....	100,000	....	332,500
Sailing	5	216,500	11	363,251	34	823,222	50	1,402,973
Tonnage	7,224	....	19,366	....	45,970	....	72,560	....
Outfit	....	14,000	....	21,000	....	53,000	....	88,000
Steamers and launches under 5 tons	42	76,100	12	14,094	9	20,479	63	[a]110,673
Boats, sail and row	608	43,065	329	29,370	971	195,599	1,908	268,034
Lighters and scows	159	75,470	131	64,856	136	121,529	426	261,855
Pile drivers	23	63,073	24	45,919	17	37,800	64	146,792
Apparatus:								
Haul seines	54	13,487	32	15,212	....	....	[b]86	28,699
Purse seines	173	69,026	4	2,950	....	....	[c]177	71,976
Gill nets	479	51,500	140	18,403	1,115	104,269	[d]1,734	174,172
Traps, stake	73	203,611	46	103,080	13	19,192	132	325,883
Traps, floating	18	34,277	2	10,500	....	....	20	44,777
Spears or gaffs	70	31	....	....	....	....	70	31
Cash on hand	....	303,000	....	135,000	....	201,000	....	639,000
Shore and accessory property	....	2,387,649	....	1,441,804	....	2,969,193	....	6,798,646
Materials used	....	2,162,276	....	674,653	....	1,003,328	....	3,840,257
Wages paid	....	1,643,556	....	768,685	....	1,653,167	....	4,065,408
Total	....	7,955,986	....	4,073,018	....	7,902,211	....	19,931,215

[a] Value of outfits included.
[b] Aggregate length of 34,658 yards.
[c] Aggregate length of 67,410 yards.
[d] Aggregate length of 499,296 yards.

Output.—The table of products shows the quantity and value of each species packed, with the size and style of cans. For the first time southeast Alaska leads in both quantity and value of pack, due to the large increase in the number of canneries operated there and the high prices realized for the cheaper grades of salmon, which are packed mainly in this section. In western Alaska there was a considerable decrease as compared with 1910, but in the other two sections the increases were more than sufficient to overcome this loss. The pack as a whole is the largest ever produced in Alaska, and it is reasonable to believe is as large as a proper conservation of the resources should permit.

OUTPUT OF SALMON FROM THE CANNERIES IN 1911, BY SPECIES AND SIZE OF CANS.[a]

Products.	Southeast Alaska.		Central Alaska.		Western Alaska.		Total.	
	Cases.	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*
Coho, or silver:								
½-pound flat	1,574	$12,588					1,574	$12,588
1-pound flat	1,075	5,844					1,075	5,844
1-pound tall	96,938	554,731	18,759	$107,278	15,562	$82,206	131,259	744,215
Total	99,587	573,163	18,759	107,278	15,562	82,206	133,908	762,647
Dog, or chum:								
1-pound flat	7,245	21,382					7,245	21,382
1-pound tall	280,313	1,037,944	9,078	34,470	27,159	105,767	316,550	1,178,181
Total	287,558	1,059,326	9,078	34,470	27,159	105,767	323,795	1,199,563
Humpback, or pink:								
½-pound flat	4,836	28,107					4,836	28,107
1-pound flat	9,437	37,748					9,437	37,748
1-pound tall	959,221	3,780,147	25,062	99,816	6,722	26,888	991,005	3,906,851
Total	973,494	3,846,002	25,062	99,816	6,722	26,888	1,005,278	3,972,706
King, or spring:								
½-pound flat	67	565					67	565
1-pound tall	1,338	7,929	15,988	105,628	28,125	180,966	45,451	294,523
Total	1,405	8,494	15,988	105,628	28,125	180,966	45,518	295,088
Red, or sockeye:								
½-pound flat	13,601	116,662					13,601	116,662
1-pound flat	4,967	34,068					4,967	34,068
1-pound tall	200,256	1,265,511	430,856	2,743,740	665,638	4,203,252	1,296,750	8,212,503
Total	218,824	1,416,241	430,856	2,743,740	665,638	4,203,252	1,315,318	8,363,233
Grand total	1,580,868	6,903,226	499,743	3,090,932	743,206	4,599,079	2,823,817	14,593,237

[a] Half-pound cases contain 48 ½-pound cans, but for convenience in comparing with the 1-pound cases, which contain 48 cans, they have been reduced one-half in number, thus equaling in weight the 1-pound cases.

Comparison of pack of 1908, 1909, 1910, and 1911.—The total pack of 1911 exceeds in both quantity and value that of any preceding year. This results from the large pack of cohos, chums, and pinks, which exceeds that of any previous season, the increase in the pack of the latter being especially noticeable. The pack of red salmon reached its maximum in 1909, since which time it has been decreasing. This is the species which has so far been the most valuable and the most assiduously sought by the packers, and apparently the limit of development in the industry it supports has been reached. Heretofore the price of chums and pinks has precluded a maximum pack of these cheaper grades. For this reason, as well as from the fact that the red salmon is more restricted in its distribution than any of the other salmon, it is to be anticipated that any decrease in the salmon supply due to excessive or improper fishing will be marked first in this species, and it will be of interest to see whether the remarkable take of pinks this season will show any effect on the run in 1913. Under any circumstances only the most conservative investment of new capital in the salmon-canning industry would seem wise, for new establishments must of necessity either only divide the catch at present made, to the possible destruction of the margin of profit and loss of both new and old investment, or overtax

the productivity of the industry by overfishing, with the result of destroying the supply before the newly invested capital can be realized upon.

COMPARISON OF THE OUTPUT OF THE SALMON CANNERIES IN 1908, 1909, 1910, AND 1911.[a]

Products.	1908		1909		1910		1911	
	Cases.	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*
Coho, or silver:								
½-pound flat	105	$627	.....	.....	163	$1,299	1,574	$12,588
1-pound flat	2,414	9,903	1,206	$5,543	2,249	12,357	1,075	5,844
1-pound tall	66,309	263,559	55,350	225,486	111,614	546,010	131,259	744,215
Total	68,828	274,089	56,556	231,029	114,026	559,666	133,908	762,647
Dog, or chum:								
1-pound flat	107	321	.....	.....	.....	.....	7,245	21,382
1-pound tall	218,406	553,876	120,712	274,110	254,218	773,409	316,550	1,178,181
Total	218,513	554,197	120,712	274,110	254,218	773,409	323,795	1,199,563
Humpback, or pink:								
½-pound flat	.....	.....	.....	.....	3,188	15,871	4,836	28,107
1-pound flat	569	1,590	.....	.....	7,900	35,550	9,437	37,748
1-pound tall	643,564	1,731,789	464,873	1,114,839	543,233	1,712,634	991,005	3,906,851
Total	644,133	1,733,379	464,873	1,114,839	554,321	1,764,055	1,005,278	3,972,706
King, or spring:								
½-pound flat	62	425	.....	.....	54	432	67	565
1-pound tall	23,667	99,442	48,034	207,624	40,167	214,370	45,451	294,523
Total	23,729	99,867	48,034	207,624	40,221	214,802	45,518	295,088
Red, or sockeye:								
½-pound flat	10,909	68,083	8,193	63,888	22,320	176,385	13,601	116,662
1-pound flat	26,950	138,120	85,193	236,609	39,941	236,453	4,967	34,068
1-pound tall	1,613,911	7,318,048	1,611,916	7,310,053	1,388,006	7,361,552	1,296,750	8,212,503
Total	1,651,770	7,524,251	1,705,302	7,610,550	1,450,267	7,774,390	1,315,318	8,363,233
Grand total	2,606,973	10,185,783	2,395,477	9,438,152	2,413,053	11,086,322	2,823,817	14,593,237

[a] The ½-pound cases have been reduced one-half in number so as to equal the 1-pound cases in weight.

The following table shows, by species, the average price received by the packer per case of 1-pound talls for a series of years. The 1-pound talls are used in this comparison because they form by far the greater part of the pack, the flats being packed in limited quantity for a special trade.

There is still room for improvement in handling the cheaper grades of salmon. The advance in price of chums and pinks is beyond question based on the fundamental appreciation by the ultimate consumer of their food value taken in comparison with the higher-priced grades. In 1909 pinks sold at $2.40 per case; in 1911 the price had risen to $3.94, with an increased production of over 100 per cent, whereas reds selling at $4.53 in 1909 increased in price only 40 per cent in 1911 and this in the face of a decreased production of 20 per cent.

AVERAGE ANNUAL PRICE PER CASE OF FORTY-EIGHT 1-POUND TALL CANS OF SALMON, 1905–1911.

Products.	1905	1906	1907	1908	1909	1910	1911
Coho, or silver	$3.20	$3.63	$3.91	$3.98	$4.07	$4.89	$5.67
Dog, or chum	2.69	2.87	2.97	2.53	2.28	3.04	3.72
Humpback, or pink	2.95	3.00	3.16	2.69	2.40	3.15	3.94
King, or spring	3.28	3.78	4.18	4.20	4.32	5.34	6.48
Red, or sockeye	3.38	3.77	4.59	4.52	4.53	5.30	6.33

PICKLING.

Under the general head of pickling are included the two processes, mild curing or light pickling and the ordinary salting or heavy pickling.

ORDINARY PICKLING OR SALTING.

Owing to the high prices prevailing for canned salmon and the correspondingly low prices for pickled or salt salmon, several salteries were turned into canneries, while in other cases the greater part of the fish caught were sold fresh to the canneries instead of being salted. A few salters shut down altogether, while still others very materially curtailed their operations. Two new plants were started, but they will likely be equipped for canning next year. Owing to the small pack, prices very materially improved late in the season. Salting salmon is a declining industry, due largely to better and more popular methods of preparing salmon for market (such as canning, freezing, and mild curing) and to the improvement in facilities for marketing the fresh fish.

In July the schooner *Jessie Minor*, supply vessel for the Lagoon Salmon Co., of Nelsons Lagoon, was wrecked in the lagoon and became a total loss.

Persons engaged.—This year 252 persons (145 fishermen, 106 shoresmen, and 1 transporter) were employed in the pickling industry, a decrease of 9 as compared with 1910.

PERSONS ENGAGED IN THE SALMON-PICKLING INDUSTRY IN 1911.

Occupation and race.	Southeast Alaska.	Central Alaska.	Western Alaska.	Total.
Fishermen:				
Whites	26	7	29	62
Indians	6	61	16	83
Total	32	68	45	145
Shoresmen:				
Whites	12	15	46	73
Japanese			2	2
Indians	9		22	31
Total	21	15	70	106
Transporters: Whites			1	1
Grand total	53	83	116	252

Investment.—There were 15 salteries (6 in southeast Alaska, 5 in central Alaska, and 4 in western Alaska) in operation, an increase of 3 over 1910. In addition, a few of the canneries and mild-curing plants also pickled their surplus catch, and while the product has been included in the present table, the men and investment could not be separated from the statistics of the other branches of the industry.

The total investment is slightly smaller than in 1910. One large steamer employed in central Alaska has been withdrawn, but the use of three sailing vessels in western Alaska more than balances the total investment in vessels as compared with the previous year. An examination of the investment in apparatus for capture of the fish reveals a very slight falling off in value; the purse seines used in southeast Alaska have very materially decreased, but the installation of a trap in western Alaska nearly restores the total. There has been a marked decrease in the total wages paid.

INVESTMENT IN THE SALMON PICKLING INDUSTRY IN 1911.

Items.	Southeast Alaska.		Central Alaska.		Western Alaska.		Total.	
	No.	*Value.*	*No.*	*Value.*	*No.*	*Value.*	*No.*	*Value.*
Salteries	6		5		4		15	
Transporting vessels:								
Steamers and launches	1	$3,000	1	$2,000	2	$4,000	4	$9,000
Tonnage	14		11		11		36	
Outfit		1,000		800		1,800		3,600
Sailing					3	18,000	3	18,000
Tonnage					749		749	
Outfit						900		900
Launches under 5 tons	5	2,900			1	3,500	6	[a] 6,400
Boats, sail and row	24	1,040	15	660	26	4,160	55	5,860
Lighters and scows	2	900	2	200	12	4,300	16	5,400
Pile drivers					1	500	1	500
Apparatus:								
Haul seines	9	925	10	1,275	2	125	[b] 21	2,325
Purse seines	5	810	1	65			[c] 6	875
Gill nets	15	800	16	635	16	1,425	[d] 47	2,860
Traps, stake	1	300			1	1,500	2	1,800
Cash capital		8,000		10,000		40,000		58,000
Shore and accessory property		15,800		14,700		22,960		53,460
Wages paid		6,730		7,177		21,101		35,008
Total		42,205		37,512		124,271		203,988

[a] Includes outfit.
[b] Aggregate length of 4,320 yards.
[c] Aggregate length of 802 yards.
[d] Aggregate length of 6,200 yards.

Output.—The output this year amounted to 9,820 barrels, valued at $118,038, a decrease of 4,585 barrels and $12,603 as compared with 1910. A portion of this output is composed of salmon bellies. A few of the backs were pickled and appear in this table, while the rest were either dried, dry-salted, or smoked, and appear under their proper headings in this report. In a comparison with the output for 1910, it will be oted that although two new salteries were established in western Alaska there was a heavy decrease in the output of pickled reds, from 11,931 barrels in 1910 to 6.239 in 1911. On the other hand, the pack of pickled pinks increased from 330 barrels in

1910 to 1,122 in 1911, with a very slight increase in the pack of pink bellies. The average value of the total pack increased from about $9 to $12 per barrel.

BARRELS[a] OF SALMON PICKLED IN 1911, BY SPECIES.

Products.	Southeast Alaska.		Central Alaska.		Western Alaska.		Total.	
	No.	*Value.*	*No.*	*Value.*	*No.*	*Value.*	*No.*	*Value.*
Coho, or silver	158	$1,499	65	$650			223	$2,149
Coho bellies	1	17	37	472			38	489
Dog, or chum	99	418	2	14	32	$234	133	666
Dog bellies	7	77					7	77
Humpback, or pink	1,118	11,214	4	24			1,122	11,238
Humpback bellies	676	5,122					676	5,122
Humpback backs	150	600					150	600
King, or spring	7	50	3	35	590	8,010	600	8,095
King bellies	2	30					2	30
King heads	1	15					1	15
Red, or sockeye	3	45	1,050	13,106	5,186	66,427	6,239	79,578
Red bellies			543	9,103	71	740	614	9,843
Red tips					15	136	15	136
Total	2,222	19,087	1,704	23,404	5,894	75,547	9,820	118,038

[a] Barrels holding 200 pounds of fish.

MILD-CURING.

At the opening of the present season the mild-curing establishments claimed to be still holding unsold a part of the previous season's pack, and some of them tried to persuade the fishermen to accept much lower prices for the raw product than had prevailed in 1910. This led to trouble in the Ketchikan section, and as a result very little mild-curing was done there. The few fishermen who trolled disposed of their catch to the Wrangell mild curers or to the shippers of fresh king salmon.

With the exception of a small quantity put up in Cook Inlet, central Alaska, the packing of mild-cured salmon was confined to southeast Alaska. While a considerable part of the pack is put up at permanent stations, a fleet of power vessels and boats engaged in the work, selling their product generally to the shore stations. Usually king salmon alone are prepared in this manner, but this year a few coho salmon were put up.

As in previous years the principal trouble the packers experienced was in making use of the white-meated king salmon. About one-fourth of the average catch of king salmon is white-meated and the fishermen insist that the dealers shall take these fish along with the others, which they do at a considerably lower price, and a few of the larger are mild-cured. Early in the season many of them, together with the small red-meated fish, are shipped fresh to Puget Sound ports, but after the kings begin to run in the sound this is unprofitable.

A red-meated female king salmon caught early in July in Gut Bay, Chatham Strait, southeast Alaska, by trolling, weighed, after removal of the head, viscera, fins, and backbone, 83½ pounds. Allowing the

usual percentage of loss in dressing, this fish must have weighed about 115 pounds when taken from the water.

Persons engaged.—This year 658 persons (576 fishermen, 55 shoresmen, and 27 transporters) were engaged in the mild-curing industry, as compared with 656 in 1910, a gain of 2. A number of others also were engaged for limited periods, but as their work in connection with other branches of the salmon industry was more important they have been included there.

PERSONS ENGAGED IN THE SALMON MILD-CURING INDUSTRY IN 1911.

Occupation and race.	Southeast Alaska.	Central Alaska.	Total.
Fishermen:			
Whites	341		341
Indians	215	20	235
Total	556	20	576
Shoresmen:			
Whites	41	4	45
Indians	10		10
Total	51	4	55
Transporters:			
Whites	24		24
Indians	3		3
Total	27		27
Grand total	644	24	658

Investment.—There were 13 fixed plants operated in Alaska this year, i. e., plants with permanent buildings and whose chief business was the mild-curing of salmon. A considerable part of this industry is carried on by schooners and launches, which move from place to place with the schools of salmon. The fish are caught by the crews from small boats and packed on board the vessels.

It will be noted that there has been practically no change in the number of establishments or of persons engaged as compared with 1910. The total investment has, however, risen from $363,818 to $419,138, which is distributed principally among the items of vessels, shore property, and cash capital. It is of interest to observe that with this increased investment in means of production the output shows only a slight increase in total pounds. The number of gill nets used is slightly increased, but the value is less than in the previous year. The increase in the value of the line equipment indicates an even greater use of that form of apparatus. This phase of the salmon industry is of especial value in that it affords labor for men with capital insufficient to engage in the other branches of the fishery, and at an opportune season. The fact that the wages paid dropped from $47,737 to $41,876 does not contradict this statement. The fish are sold by piece.

INVESTMENT IN THE SALMON MILD-CURING INDUSTRY IN 1911.

Items.	Southeast Alaska.		Central Alaska.		Total.	
	No.	Value.	No.	Value.	No.	Value.
Fixed plants	13				13	
Steamers and launches (over 5 tons)	28	$72,700	1	$2,500	29	$75,200
Tonnage	245		25		270	
Outfit		31,000		2,000		33,000
Sailing vessels	1	2,000			1	2,000
Tonnage	36				36	
Outfit		400				400
Steamers and launches (under 5 tons)	39	73,400			39	a 73,400
Boats, sail and row	346	12,400	15	600	361	13,000
Scows	24	12,750			24	12,750
Apparatus:						
Gill nets	158	24,275	15	375	173	b 24,650
Lines, trolling		662				662
Shore and accessory property		50,200				50,200
Cash capital		90,000		2,000		92,000
Wages paid		40,676		1,200		41,876
Total		410,463		8,675		419,138

a Includes outfit. b Aggregate length of 56,950 yards.

Products.—The pack this year amounted to 3,164 tierces, valued at $286,041, a decrease in quantity of 193 tierces and an increase in value of $65,368 as compared with 1910. Fifty-nine tierces of coho salmon were packed this year, while none was put up in 1910.

PRODUCTS OF THE SALMON MILD-CURING INDUSTRY IN 1911.

Species.	Tierces.	Weight.	Value.
Southeast Alaska:		Pounds.	
King salmon	3,060	2,502,395	$280,697
Coho salmon	59	49,228	2,464
Total	3,119	2,551,623	283,161
Central Alaska: King salmon	45	36,000	2,880
Total:			
King salmon	3,105	2,538,395	283,577
Coho salmon	59	49,228	2,464
Grand total	3,164	2,587,623	286,041

FRESH SALMON.

As in previous years, large quantities of king salmon (mainly white-meated and small red-meated fish) were shipped fresh to Puget Sound ports, where they brought exceptionally good prices. In addition, other species of salmon were shipped by certain of the fishermen, this branch of the industry centering mainly about Wrangell and Petersburg. Quite a number of salmon are also disposed of locally to mining camps or through the markets in the various towns. Most of the kings and cohos were caught by trolling, while others were taken in seines, traps, and gill nets.

A large number of cohos were caught late in July and early in August in the bays along the lower part of Chatham Strait, and the fishermen report that these had been feeding on shrimp, and it was

found necessary to eviscerate the fish immediately, as otherwise the belly would be burned through by the food in the stomach.

The following table sets out by species the quantity and value of salmon marketed fresh.

FRESH SALMON MARKETED FROM ALASKA IN 1911.

Species.	Number.	Pounds.	Value.
Southeast Alaska:			
Coho salmon	6,900	41,400	$872
Dog salmon	300	2,400	48
Humpback salmon	8,000	32,000	400
King salmon	79,464	1,748,212	103,504
Red salmon	11,712	58,560	2,758
Total	106,376	1,882,572	107,582
Central Alaska:			
Coho salmon	1,333	8,000	240
King salmon	228	5,000	200
Red salmon	5,000	30,000	900
Total	6,561	43,000	1,340
Grand total	112,937	1,925,572	108,922

MINOR PRESERVING PROCESSES.

FREEZING.

There were 3 plants engaged in freezing salmon this year, 2 in southeast Alaska and 1 in central Alaska, this latter a floating plant. The schooner *Metha Nelson*, owned by Erskine & Fletcher, of Kodiak, was fitted out for cold storage and operated around Kodiak Island; salmon, trout, and halibut were the species handled. Freezing halibut is the principal business at all but one of these plants. The following table shows the pack of frozen salmon:

FROZEN SALMON PACKED IN ALASKA IN 1911.

Species.	Pounds.	Value.
Southeast Alaska:		
King salmon (red-meated)	59,766	$4,184
King salmon (white-meated)	14,459	434
Coho salmon	264,352	10,574
Dog salmon	33,708	674
Humpback salmon	5,956	119
Red salmon	3,225	97
Total	381,466	16,082
Central Alaska:		
Coho salmon	48,546	1,942
Grand total	430,012	18,024

DRY-SALTING AND DRYING.

At a few places in central Alaska the bellies of red and coho salmon are cut out and pickled, after which the backs are dried in the sun and

the resulting product, called "ukalu," is used for fox food at the fox ranches and for dog food.

There is a small local demand for this latter purpose where team dogs are used. It would seem that the heads and tails from the canneries could be well utilized for this purpose, but it was remarked that this season in Nushagak Bay, where a dearth of salmon for this purpose existed, at only one village was there any attempt made to secure a supply in this manner. For this purpose, or even for food, the native prefers to take fish on the spawning ground. At that time the oils of the flesh have largely gone into the reproductive products, thus creating a choice delicacy for food and at the same time rendering the flesh more easily dried, a matter of no small moment in a climate with but few rainless days.

In southeast Alaska 80,000 pounds of humpback backs, valued at $800, were prepared for food. The dry-salting of dog salmon for food, which at one time was quite an industry in Alaska, has almost ceased; only 33,285 pounds, valued at $1,340, were so prepared this year.

SMOKING.

A delicious smoked product, known locally as "beleke," is prepared at Kodiak and several other places from the backs of red and coho salmon. At one cannery the experiment was made of preparing a mild-smoked salmon and canning it. The result was a smoked fish of peculiar richness and delicacy. Whether at present it could be produced in commercial quantity at a marketable price is doubtful, but in view of the early excessive supply of fish obtained by the present processes it is well to consider any means of converting some portion of that supply into a product which will command an increased price. The quantity of "beleke" put up this year amounted to 14,200 pounds of red salmon backs, valued at $1,420, and 1,800 pounds of coho backs, valued at $180. In addition, 5,000 pounds of smoked humpback salmon, valued at $100, and 3,787 pounds of dog salmon, valued at $75, were prepared in southeast Alaska.

COD FISHERY.

GENERAL CONDITIONS.

All but one of the firms and individuals (John H. Nelson, of Squaw Harbor) operating in the district for cod exclusively have their headquarters at San Francisco, Cal., or Seattle, Anacortes, or Tacoma, Wash., at which places or in their immediate vicinity the cured fish are received and prepared for marketing. Some of the operators have shore stations located at favorable places in central Alaska on the Shumagin and Sannak Islands and Unimak Island. Thence the dory fishermen carry on their operations, bringing in their catch

daily, and when they have accumulated enough to form a cargo a vessel is dispatched from the home port or else a fishing vessel completes its fare from the station catch and carries the fish to the curing establishments in the States.

A shortage of codfish on the Atlantic coast, as a result of which considerable quantities of Pacific codfish were sold in that region, very much helped the industry this year; otherwise there would have been a surplus which might have caused a break in the remunerative prices prevailing just now.

One new company entered the industry this year, the Pacific Coast Codfish Co., of Seattle, Wash., under management formerly connected with the Seattle-Alaska Fish Co., which sold out its business last year to the Western Codfish Co., of Seattle. The new company sent north to the fishing banks the schooner *John A.*

The Pacific States Trading Co., of San Francisco, which has been out of the codfish business for a couple of years, resumed operations this year, sending north the schooner *Ottillie Fjord.* In the fall the company's station at Northwest Harbor was reopened, and it is probable that two new stations will be established next year.

A serious handicap under which the fishing vessels labor at present is the lack of doctors in the sections of Alaska which they frequent. These sections are very sparsely settled, and when a serious illness develops aboard ship the captain has to cut short his trip and make for his home port or else make a trip of several hundred miles each way to the nearest doctor. The Revenue-Cutter Service operates several cutters around the Pribilof Islands, and if these or an additional cutter could be directed to make periodical trips over the banks, they could afford medical aid that would mitigate the suffering amongst the cod fishermen and prevent the heavy financial loss caused the owners through a broken trip.

During a terrific gale the night of February 15, 1911, the Union Fish Co.'s schooner *Czarina,* en route from San Francisco to the Shumagin Islands, was wrecked on Nagai Island and became a total loss. The crew was saved.

Two cod fishermen were washed overboard and lost this year, one from the schooner *John A* and the other from the schooner *Vega.*

STATISTICS FOR SHORE STATIONS.

During 1911 the following shore stations were operated: Alaska Codfish Co.: Unga, Baralof (Squaw Harbor), and Kelleys Rock (Winchester), on Unga Island, and Companys Harbor and Moffats Cove, on Sannak Island. John H. Nelson: Squaw Harbor, Unga Island. Pacific States Trading Co.: Northwest Harbor, Little Koniuji Island. Union Fish Co.: Pirate Cove, Popof Island; Northwest Harbor,

Little Koniuji Island; Pavlof Harbor and Johnson Harbor, on Sannak Island; Sanborn Harbor, on Nagai Island; and Unga, on Unga Island.

During the year 201 fishermen, 24 shoresmen, and 59 transporters were employed. The total investment amounted to $215,670. The catch amounted to 3,597,288 pounds of prepared products, valued at $108,790. This is over 50 per cent increase over the output of 1910. It was secured by practically the same number of fishermen; the chief increase in equipment and labor was in the transportation branch.

PERSONS ENGAGED IN THE CENTRAL ALASKA COD FISHERIES IN 1911.

Occupation and race.	Number.
Fishermen: Whites	201
Shoresmen:	
Whites	15
Indians	8
Chinese	1
Total	24
Transporters: Whites	59
Grand total	284

INVESTMENT IN THE CENTRAL ALASKA COD FISHERIES IN 1911.

Items.	Number.	Value.	Items.	Number.	Value.
Transporting vessels:			Boats, sail and row	193	$5,790
Steamers and launches	3	$28,000	Apparatus: Hand lines		1,575
Tonnage	78		Cash capital		44,000
Outfit		3,500	Stations with accessory property		48,705
Sailing	6	80,000			
Tonnage	1,318				
Outfit		4,100	Total		215,670

PRODUCTS OF THE CENTRAL ALASKA COD FISHERIES IN 1911.

Products.	Prepared weight.	Value.
	Pounds.	
Cod, fresh	20,000	$800
Cod, salted	3,575,588	107,862
Cod, pickled	900	48
Cod tongues, pickled	800	80
Total	3,597,288	108,790

VESSEL FISHING.

The following fleet[a] of 10 vessels, with headquarters in California and Washington, fished in Alaskan waters this year:

Name.	Class.	Net tonnage.	Owners.
Fanny Dutard	Schooner	252	Matheson Fisheries Co., Anacortes, Wash.
Alice	do	220	Robinson Fisheries Co., Anacortes, Wash.
Joseph Russ	do	235	Do.
Maid of Orleans	do	171	Western Codfish Co., Seattle, Wash.
Vega	do	233	Do.
John A	do	235	Pacific Coast Codfish Co., Seattle, Wash.
Fortuna	do	138	Blom Codfish Co., Tacoma, Wash.
W. H. Dimond	do	376	Alaska Codfish Co., San Francisco, Cal.
Ottillie Fjord	do	247	Pacific States Trading Co., San Francisco, Cal.
City of Papeete	Barkentine	370	Alaska Codfish Co., San Francisco, Cal.

The vessels from Washington operating in Alaskan waters caught 1,101,000 fish, with a cured weight of 5,378,000 pounds, valued at $161,340, while those from California caught 466,000 fish, with a cured weight of 2,330,000 pounds, valued at $69,900.

HALIBUT FISHERY.

GENERAL CONDITIONS.

A large part of the halibut taken from the waters of Alaska and adjacent offshore grounds are landed directly in the home ports without entering any Alaskan port. No statistics for this catch have been compiled, and the figures in the following tables pertain entirely to the inshore fishery or fish landed in and shipped from Alaskan ports.

Most of the fishing done by Alaskan vessels is prosecuted from September to May, but during the last few years a number of vessels and boats have fished continuously throughout the year for the freezing plants of southeast Alaska. During the winter season the greater part of the catch is shipped fresh to Puget Sound ports, whence it is distributed throughout the country.

Several vessels from the Juneau fleet fished in the spring on an ocean bank about 15 miles west of Lisianski Strait, southeast Alaska. This is thought to be a good-sized bank, and the halibut appear to be fairly numerous.

During the summer the Bureau of Fisheries steamer *Albatross* surveyed the known halibut banks in the north Pacific Ocean and in Bering Sea, and also prospected for new banks. The results of this work have been published as Bureau of Fisheries Document 763.

[a] None of the data relating to this fleet appears in the statistical tables.

The Taku Canning & Cold Storage Co., which operates a salmon cannery at Taku Harbor, southeast Alaska, canned some halibut this year. The Revilla Fish Products Co. of Ketchikan expects to engage regularly in canning halibut next season.

In previous years halibut were taken in the waters of central Alaska for local consumption only. This year the schooner *Metha Nelson*, which was operated as a floating freezer, put up, in addition to other species, some frozen halibut.

As heretofore, the halibut fleet was very much hampered in its operations by the lack of bait during the winter months. At this season, owing to the inclement weather which prevents the bait fishermen from working and the scarcity of herring, fresh bait is difficult to procure and vessels are frequently laid up for days at a time waiting for this necessary article. Salt bait is used when absolutely necessary, but it has never proved very successful.

The most feasible method for overcoming this condition of affairs would be the establishment of small freezers at Juneau, Hoonah or Killisnoo, Scow Bay or Petersburg, Wrangell, and Ketchikan, where herring received from the fishermen during the summer and early fall, when most abundant, could be frozen and stored until needed in the late fall and winter. The New England Fish Co., at its Ketchikan plant, freezes a large quantity of herring each year, which supplies bait to its own vessels and to the small vessels which deliver their catches of halibut to its plant.

STATISTICS.

During the year there were 651 persons employed in all branches of the industry. The total investment was $1,194,073. The prepared weight of the catch amounted to 17,315,171 pounds, which sold for $822,362, a small increase in the total over 1910, but a slight decrease in the output of southeast Alaska. There was a slight falling off in the number of vessel fishermen, while there was little over half the number of shore fishermen employed. With this may be noted a marked decrease in the number of small launches, bringing about a slightly smaller total investment in the fishery in spite of a heavier valuation of the larger vessels and shore property. In this connection it should be stated that the shipments reported by the Puget Sound fleet operating in Alaska fell from 3,531,644 pounds in 1910 to 2,399,379 pounds in 1911. These figures may indicate the beginning of a depletion of the southeast Alaska inshore halibut banks. Central Alaska this year furnished 89,479 pounds, the first product of the western banks.

PERSONS ENGAGED (EXCEPT ON STEAMERS) IN THE ALASKA HALIBUT FISHERIES IN 1911.

Occupation and race.	Southeast Alaska.	Central Alaska.	Total.
Fishermen:			
Vessel fisheries—			
Whites	320		320
Indians	43	12	55
Total	363	12	375
Shore fisheries—			
Whites	150	4	154
Indians	81		81
Total	231	4	235
Shoresmen:			
Whites	29		29
Indians	5		5
Total	34		34
Transporters: Whites	3	4	7
Grand total	631	20	651

INVESTMENT (EXCEPT STEAMERS) IN THE ALASKA HALIBUT FISHERIES IN 1911.

Items.	Southeast Alaska.		Central Alaska.		Total.	
	No.	*Value.*	*No.*	*Value.*	*No.*	*Value.*
Fishing vessels:						
Steamers and launches	61	$476,330	1	$7,500	62	$483,830
Tonnage	862		40		702	
Outfit		200,846		1,200		202,046
Launches under 5 tons	87	150,525			87	[a] 150,525
Boats, sail and row	9	290			9	290
Scows	6	7,600			6	7,600
Apparatus:						
Vessel fisheries, trawl lines		22,370		307		22,677
Shore fisheries, trawl lines		9,605				9,605
Cash capital		47,000				47,000
Shore and accessory property		270,500				270,500
Total		1,185,066		9,007		1,194,073

[a] Includes outfit.

PRODUCTS (EXCEPT FROM STEAMERS) OF THE ALASKA HALIBUT FISHERIES IN 1911.

Products.	Southeast Alaska.		Central Alaska.		Total.	
	Prepared weights.	Value.	Prepared weights.	Value.	Prepared weights.	Value.
Vessel catch:	*Pounds.*		*Pounds.*		*Pounds.*	
Halibut, fresh	13,336,783	$658,935			13,336,783	$658,935
Halibut, frozen	2,607,296	102,281	29,479	$884	2,636,775	103,165
Halibut, fletched	51,957	2,089			51,957	2,089
Total	15,996,036	763,305	29,479	884	16,025,515	764,189
Shore catch:						
Halibut, fresh	914,894	43,076	60,000	2,400	974,894	45,476
Halibut, frozen	289,699	11,365			289,699	11,365
Halibut, fletched	17,319	696			17,319	696
Halibut, pickled	400	24			400	24
Halibut, canned	[a] 7,344	612			7,344	612
Halibut fins, pickled	400	8			400	8
Total	1,230,056	55,781	60,000	2,400	1,290,056	58,181
Grand total	17,226,092	819,086	89,479	3,284	17,315,571	822,370

[a] 153 cases (48 to case) 1-pound cans.

PUGET SOUND FISHING FLEET.

A fleet of Puget Sound power vessels visits southeast Alaska during the months from October to March, when, owing to stormy weather and a scarcity of fish, it is not safe nor profitable to visit the banks near the home ports. This fleet makes its headquarters at Petersburg, Juneau, and Ketchikan, shipping the catch home from these places via the regular steamship lines. As a result of its operations in Alaska the fleet (with the exception of the steamers) caught and shipped 2,399,379 dressed pounds of fresh halibut, valued at $118,488. The steamers carry their own catches to the sound ports, and these have not been included in the above amount. During the summer months most of this fleet fishes on the Flattery Banks off the State of Washington, or the banks off the British Columbia coast. None of these data are included in the statistical tables of this report.

HERRING FISHERY.

GENERAL CONDITIONS.

The partial failure of the British Columbia herring fisheries during 1910 and 1911 brought to the fore the abundant supplies of Alaska herring. As a result several new plants for the preparation of herring for food were established in southeast Alaska, and the pack prepared very materially exceeded that of any other year.

One result of this increase in the number of herring plants has been the introduction of Japanese fishermen. Under the provisions of the act to prevent aliens from fishing in the waters of Alaska, Japanese can not fish independently, but it is an easy matter to secure the aid of some venal Americans who will pose as stockholders and thus secure an American incorporation, or pose as the owners of the plant, and thus legalize the employment of Japanese (who are the real owners) as fishermen and shore employees.

The experience of British Columbia with Japanese fishermen has been a most unfortunate one, and the same may be said of our own territory of Hawaii. British Columbia is now endeavoring to solve the problem, and as two of the three coast States have already imposed serious restrictions, the Japanese fishermen are seeking to establish themselves in Alaska. Unless radical measures are soon taken American fishermen will find serious difficulty in competing with the Japanese, while the fisheries will undoubtedly suffer as a result of the latter's destructive methods.

For a number of years a large plant for the preparation of oil and fertilizer from herring and other fishes has been operated at Killisnoo, in southeast Alaska. During the same period other plants were established and operated for a season or two at various places in the

same section of the District, but these have been discontinued. The company at present operating was organized in 1889, but the industry is reported to have been pursued without substantial returns until 1909, 20 years later. Now that the herring of Puget Sound and British Columbia waters are less abundant, the herring of Alaska are being looked to to supply the deficit, and it is hoped that the next few years may witness a great expansion of the industry in our waters. The chief demand is from the Orient.

As in other places, the herring of Alaska vary considerably in size, and so far from being a handicap, as is now claimed by some, this should eventually prove one of the most valuable features of the industry by permitting diversity in utilization. In Maine, where the preparation of herring for food has been brought to a high state of perfection, every size is put to a commercial use. The smaller ones are canned as sardines, while the medium and larger sizes are pickled and smoked. At the present time Alaska pickled herring commands as good a price as the corresponding grade of Atlantic herring.

During July and August the herring of southeast Alaska, and possibly other sections of the District, feed quite largely upon small crustaceans known as "red feed". If the fish is killed when its stomach is filled with the "red feed" the flesh rapidly decomposes, especially the belly, and it presents such a poor appearance when pickled that its value is seriously depreciated. This same trouble is met with wherever the sea herring is caught. In Maine it is not a serious matter, as most of the herring are caught in weirs in which the fish can be retained until they have digested the food. If traps were used in Alaska during July and August for the capture of herring, the fish could easily be held alive in the same manner as in the weirs and this handicap thus be overcome. During the rest of the year its food does not affect its preservation unfavorably.

An interesting report has recently been made by the American consul at Stavanger, Norway, on the herring industry of that country, published in the Daily Consular and Trade Reports for April 9, 1912. It is therein stated that further investment is being made in small plants to produce herring flour and oil. The flour or meal is the product from the solid portion of the fish after the oil is expressed. It is used as feed for cattle and hogs as well as for fertilizer. The oil is much used in paints as a substitute for linseed oil. The establishment of these plants is strongly urged to enable use to be made of the surplus fish which can not be marketed as food. Under present conditions the markets are overstocked and often large quantities of fresh herring shipped to England are thrown overboard and wasted for want of a market.

If this fish meal proves to be a valuable stock food as well as fertilizer, it may become of value in Alaska to the agricultural resources of the territory.

Aside from the fact that the herring fisheries of Alaska offer in themselves a present and future supply of food fish, they are also important in other ways. Herring, as is well known, is the only uniformly successful bait that has been found for halibut, and without a good supply for this purpose the great halibut industry, which at present is growing very rapidly, would soon dwindle to almost nothing. Herring also has been found to be the most successful bait in trolling for king salmon, an industry that at present is giving support to hundreds of fishermen and others in southeast Alaska. The bait supply, however, is not the only important feature, for there is the additional and very important fact that it is principally the presence of big schools of herring that serves to attract the king and coho salmon into the protected waters of southeast Alaska before they are ready to spawn, and makes it possible for the salmon trollers to catch king and coho salmon in almost every month in the year.

STATISTICS.

Persons engaged.—There were 265 persons employed this year, a gain of 78 over 1910. A notable feature of the table is the increase in the number of Japanese fishermen and shoresmen employed. In 1910 there were 4 Japanese fishermen and 6 shoresmen employed, while this year there were 26 Japanese fishermen and 7 shoresmen engaged.

Persons Engaged in the Alaska Herring Fisheries in 1911.

Occupation and race.	Southeast Alaska.	Central Alaska.	Total.
Fishermen:			
Whites	99	9	108
Indians	12		12
Japanese	26		26
Total	137	9	146
Shoresmen:			
Whites	79		79
Indians	28		28
Japanese	7		7
Total	114		114
Transporters—Whites	5		5
Grand total	256	9	265

Investments.—The total investment this year amounted to $295,220, a gain of $90,185 over 1910.

INVESTMENT IN THE ALASKA HERRING FISHERIES IN 1911.

Items.	Southeast Alaska.		Central Alaska.		Total.	
	No.	*Value.*	*No.*	*Value.*	*No.*	*Value.*
Fishing vessels:						
Steamers and launches	7	$38,500			7	$38,500
Tonnage	199				199	
Outfit		7,500				7,500
Sailing	2	7,000			2	7,000
Tonnage	1,939				1,939	
Outfit		500				500
Launches under 5 tons	13	22,800	1	$1,200	a 14	24,000
Boats, sail and row	44	2,370	4	400	48	2,770
Scows	17	11,450	1	300	18	11,750
Pile drivers	2	1,500			2	1,500
Apparatus:						
Haul seines	1	300			b 1	300
Purse seines	23	11,400			c 23	11,400
Gill nets	5	600	3	400	d 8	1,000
Traps, stake	1	1,500			1	1,500
Cash capital		75,000		2,000		77,000
Shore and accessory property		105,500		5,000		110,500
Total		285,920		9,300		295,220

a Includes outfit.
b Aggregate length of 200 yards.
c Aggregate length of 5,890 yards.
d Aggregate length of 2,600 yards.

Products.—The total value of the products sold amounted to $201,909, a gain of $86,144 over 1910. Every method of preparation shows a gain over 1910, the increases being especially noticeable in fresh bait herring, pickled for food, dry-salted for food, dried eggs, fertilizer, and oil. The increase in the dry-salted for food alone was was from 45,600 pounds, valued at $954, in 1910, to 2,027,770 pounds, valued at $16,603, in 1911.

PRODUCTS OF THE ALASKA HERRING FISHERIES IN 1911.

Products.	Southeast Alaska.		Central Alaska.		Total.	
	Quantity.	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*
Herring, fresh, for food.....pounds..	18,645	$990			18,645	$990
Herring, fresh, for bait.........do....	1,139,850	7,260			1,139,850	7,260
Herring, frozen, for bait........do....	750,146	4,500			750,146	4,500
Herring, pickled, for food..barrels..	3,901	26,428	750	$4,500	4,651	30,928
Herring, pickled, for bait.......do....	2,080	3,968			2,080	3,968
Herring, dry-salted, for food.pounds..	2,027,770	16.603			2,027,770	16,603
Herring eggs, dried, for food...do....	12,000	600			12,000	600
Herring fertilizer..............do....	3,520,000	61,600			3,520,000	61,600
Herring oil.................gallons..	343,000	75,460			343,000	75,460
Total		197,409		4,500		201,909

FERTILIZER AND OILS.

Four plants were operated this year for the manufacture of oil or fertilizer or both from fishery products, viz: Alaska Oil & Guano Co., Killisnoo; Revilla Reduction Works, Ketchikan; W. H. Royden, with a floating plant; and the Tyee Co., with a floating and permanent whaling plant. The operations of the first-named company have been shown under the herring fishery.

The Revilla Reduction Works began business the latter part of 1910, but it was found difficult to secure a sufficient supply of shark and dogfish livers to operate the plant, and the business was abandoned late in 1911. It is the intention to convert the establishment into a cannery for the preparation of special fish products. Mr. W. H. Royden operated the large house-scow *Elliott*, which he moved from place to place, and prepared oil from the livers of sharks and dogfish, incidentally handling such salmon and halibut as were required for bait or were taken on the shark lines.

The Tyee Co., which is the only company in Alaska engaged in what is called "shore whaling," has a permanent station at Tyee, in southeast Alaska. As the station is situated some distance from the ocean it was found inconvenient to operate. This season the oil-making machinery was placed aboard a large barge and during the first half of the season whaling was carried on in the neighborhood of Kodiak Island, the catch cut up aboard this barge, and the oil tried out. No attempt was made to prepare fertilizer as in previous years. Later in the season the floating station was towed to southeast Alaska and operated there.

THE TROUT FISHERY.

The State of Washington having removed its restrictions upon the importation and sale of fresh Alaska Dolly Varden trout 10 or more inches in length, a few fishermen made small shipments this year, and it is probable that the industry will ultimately grow to one of considerable magnitude. At present there is no special fishery for this fish and the catch made is in connection with that of other species.

At the present time the waters of Alaska teem with trout, particularly the Dolly Varden trout. They are so numerous that they doubtless do great damage to the salmon by devouring enormous numbers of the eggs and fry of these more valuable fishes. Under the conditions now obtaining their destruction, like that of the dogfish, may be looked upon as an advantage to the general fishery interests in Alaska.

There are five species of trout known from Alaska, namely, steelhead, Dolly Varden or salmon trout, cutthroat, rainbow, and lake. At present the steelhead is put to the most varied uses, being marketed fresh, frozen, pickled, and canned. The other species are all marketed fresh.

PRODUCTS OF THE ALASKA TROUT FISHERY IN 1911.

Sections and species.	Fresh.		Frozen.		Canned.		Pickled.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Cases.*	*Value.*	*Pounds.*	*Value.*
Southeast Alaska:								
Cutthroat	800	$40						
Dolly Varden	49,000	2,000					1,150	$66
Rainbow	7,000	280						
Steelhead	6,000	240	20,921	$1,883	10	$58		
Total	62,800	2,560	20,921	1,883	10	58	1,150	66
Central Alaska:								
Dolly Varden	23,000	1,150	1,271	65				
Steelhead			222	12	17	99	300	15
Total	23,000	1,150	1,493	77	17	99	300	15
Grand total:								
Cutthroat	800	40						
Dolly Varden	72,000	3,150	1,271	65				
Rainbow	7,000	280						
Steelhead	6,000	240	22,143	1,895	27	157	1,450	81
Total	85,800	3,710	23,414	1,960	[a] 27	157	1,450	81

[a] Each case contains 48 1-pound tall cans.

LICENSE TAXES ON FISHERY PRODUCTS.

Under the provisions of the fishery law of 1906 the salmon packers and fertilizer and fish-oil manufacturers in Alaska are required to pay license fees based on the amount of business done. The granting of these licenses and the collection of the fees is in the hands of the clerk of the court of the judicial district in which the packer is operating. The law literally requires the operator to pay the license fee in advance, but as the fee is based upon the amount of the product and it would be impossible in such an uncertain industry as fishing to estimate the output in advance, it is the custom to require only the application for a license before beginning operations and then at the end of the season a return of the amount due the district.

The following table shows the quantity of taxable fishery products prepared, the stated license tax on the product, and the total amount of tax due on each. The last item is approximate, being based upon returns on file at this Bureau, nearly all of which are sworn statements, but a few are only estimated, and therefore the total may vary somewhat from the returns sent to the clerk of the court. It is not probable, however, that the amount given will differ much either way from the correct amount as shown by the returns of the clerks:

LICENSE TAXES ON ALASKA FISHERY PRODUCTS.

Items.	Unit of quantity.	Quantity prepared.	License tax per unit of quantity.	Estimated amount of tax due.
Canned salmon	Cases	2,823,817	$0.04	$112,952.68
Pickled salmon	Barrels	9,820	.10	982.00
Mild-cured salmon	Tierces [a]	3,164	.40	1,265.60
Dry-salted salmon in bulk	100 pounds	113,313	.05	56.65
Fish oil	Barrels	7,231	.10	723.10
Fertilizer, from fish	Tons	1,760	.20	352.00
Total				116,332.03

[a] As the net weight of a tierce of fish is 800 pounds, this item is figured on a basis of 4 barrels to the tierce in working out the amount of tax.

FISH CULTURE IN ALASKA.

By Ward T. Bower,
Inspector, Alaska Salmon Fisheries.

THE HATCHERIES AND THEIR OUTPUT.

Of the seven salmon hatcheries operated in Alaska during the season 1910–11, two are owned by the Government and five by private companies. The present combined normal capacity of the Federal stations is 144,000,000 red salmon eggs, while of the private hatcheries it is 189,000,000, or a total capacity of 333,000,000 for all Alaska hatcheries. There has been no change in the number of stations operated since the completion of the Government hatchery at Afognak in 1908. The following table enumerates the hatcheries operated in 1911 and gives their present normal capacity:

Salmon Hatcheries Operated in Alaska in 1911.

Name.	Location.	Owner and operator.	Present normal capacity (red salmon eggs).
Yes Lake	Yes Lake	United States Bureau of Fisheries	72,000,000
Afognak	Afognak Island	....do	72,000,000
Fortmann	Naha Stream	Alaska Packers Association	110,000,000
Karluk	Karluk River	....do	48,000,000
Klawak	Klawak Lake	North Pacific Trading & Packing Co. and North Alaska Salmon Co.	8,000,000
Hetta	Hetta Lake	Northwestern Fisheries Co	11,000,000
Quadra	Quadra Lake	....do	12,000,000
			333,000,000

As stated in subsequent pages, the basis for reckoning numbers of fish eggs is not the same at Government and private hatcheries. Accepting the figures as furnished, however, the output of the hatcheries during the fiscal year ended June 30, 1911, was in round numbers 190,000,000 eggs and fry, or a decrease of approximately 65,000,000 from the fiscal year 1910. However, the coming season will show much improvement, as the total take of 269,666,800 eggs during the fall of 1911 is 55,000,000 more than the take of 1910. In fact, the take of 1911 is only a few thousand less than the take of 1909, the largest recorded.

OUTPUT OF THE SALMON HATCHERIES OF ALASKA IN 1911, WITH QUANTITIES OF EGGS TAKEN IN 1911-12.

Hatcheries.	Year ended June 30, 1911.[a]				Eggs taken 1911-12.		
	Red or sockeye.		Humpback or pink.		Red or sockeye.	Hump-back or pink.	Coho or silver.
	Eggs taken.	Fry liberated.	Eggs taken.	Fry liberated.			
Yes Lake	72,000,000	[b] 68,239,900	114,000	(c)	[d] 72,000,000		
Afognak	30,725,000	26,755,000	405,000	364,150	30,520,000	6,472,000	224,700
Fortmann	34,920,000	30,245,000			107,520,000		
Karluk	49,626,000	37,722,000			41,026,800		
Klawak	6,786,500	6,200,000			5,600,000		
Hetta	9,141,000	8,552,500			2,000,000		
Quadra	11,200,000	10,350,000			11,000,000		
Total	214,398,500	188,064,400	519,000	364,150	269,666,800	6,472,000	224,700

[a] Any fry held over after June 30 are included to make the record complete by seasons.
[b] 1,500,000 sockeye eggs shipped to Columbia River waters.
[c] 100,000 humpback eggs shipped to Puget Sound waters.
[d] 2,000,000 sockeye eggs shipped to Columbia River waters.

HATCHERY REBATES.

Under existing legislation owners of private salmon hatcheries are relieved from all license fees and taxation at the rate of 10 cases of canned salmon for every thousand red or king salmon fry liberated.

The following table shows the name of the owner, location of each private salmon hatchery operated during the year ending June 30, 1911, the number of salmon (red) liberated, and the amount of rebate certificates due each hatchery; these rebate certificates being available to pay license fees on products prepared for market:

REBATES CREDITED TO PRIVATE SALMON HATCHERIES DURING FISCAL YEAR ENDED JUNE 30, 1911.[a]

Owners.	Location.	Red salmon fry liberated.	Rebate due.
Alaska Packers Association	Naha Stream	40,245,000	$16,098
Do	Karluk Stream	41,270,000	16,508
Northwestern Fisheries Co	Quadra Lake	10,350,000	4,140
Do	Hetta Lake	8,552,500	3,421
North Pacific Trading & Packing Co. and North Alaska Salmon Co.	Klawak Lake	6,200,000	2,480
Total		106,617,500	42,647

[a] In the case of the hatcheries where the seasonal distribution of fry is not completed before July 1, the remaining fry are shown in the subsequent fiscal year's report.

HATCHERY EQUIPMENT AND METHODS.

Under this head it is intended to refer briefly to the more important features of the work at each station, both Government and private establishments. All of the five private hatcheries were inspected during the year by agents of the Bureau of Fisheries, and with the augmented force of the Alaska Fisheries Service, a contin-

uance of this plan of careful inspection is contemplated. As elsewhere stated, however, the whole question of private hatcheries in Alaska seems most satisfactorily met by their discontinuance as such, to be taken over and operated by the Government through the Bureau of Fisheries.

GOVERNMENT STATIONS.

YES LAKE.

Egg taking at Yes Lake is confined almost solely to the month of September. During the fall of 1910 and again in 1911 the hatchery was filled to its capacity of 72,000,000 red salmon eggs. It is noteworthy that the collection has been larger during the past two seasons than during the four prior seasons the station has been operated. This improved condition is considered as an indication of the benefits of artificial propagation. A few humpback salmon eggs have also been taken.

At Yes Lake the egg-hatching period continues from December until about the middle of April. Planting of the earlier fry is begun in February. All fry are deposited in the stream and lake near the hatchery. Last season the loss of eggs was about 5 per cent. Much of this was attributed to the extra handlings given the adult fish prior to spawning, handlings which could not be avoided owing to the unusually low water.

With a view to the infusion of new blood into Columbia River waters, two shipments of red salmon eggs were made from the Yes Lake station to Oregon. The first shipment of 1,500,000 was in the fall of 1910, and the second shipment, numbering 2,000,000, was made during the fall of 1911.

The feeding of red salmon fry on canned herring roe was undertaken in an experimental way but without success. The fish became very thin and emaciated and the loss was quite heavy. As soon, however, as they were fed Dolly Varden trout ground up raw, the young salmon did well, and by the first of September they were about 2 inches long. Before another season it is purposed to construct quite a number of additional troughs wherein to feed and rear a large number of salmon until they reach a length of from 1½ to 2 inches before being planted.

The rack across the stream near the station is upwards of 200 feet long. It is erected on a permanent apron embedded in the stream. All pieces are numbered and are so arranged when taken out in the fall that they will be in regular order for use when the rack is put in again the succeeding season. This plan greatly facilitates the operation, and it might well be adopted at other stations where it is not already in vogue.

During the year there has been considerable outlay at the station in the way of permanent improvements, including the erection of an additional building for housing the employees, also the construction of a retaining wall along the bank of the stream adjoining the hatchery grounds. The application of white paint to the interior of the hatchery, including the outsides of the troughs and the trough standards, makes the hatching room much lighter and more convenient to work in.

An order of the President dated February 1, 1906, set apart and reserved as a site for the Yes Lake salmon hatchery certain described land and water areas, including Yes Lake and its catchment basin, its outlet, and portions of the shore lands thereof, a total of approximately 55 square miles. In pursuance of this order, regulations were established prohibiting fishing operations in the reserved waters at all times other than when the run of salmon into the lake appeared to be in excess of the number required to fill the hatchery to its capacity. During the run of salmon each season a deputy is stationed on the bay to see that the regulations are observed.

Following are condensed meteorological data secured at the Yes Lake station during the fiscal year 1911:

METEOROLOGICAL OBSERVATIONS AT YES BAY.

Months.	Air.		Water.		Rainfall.
	Maximum.	Minimum.	Maximum.	Minimum.	
1910.					*Inches.*
July	74	51	53	41	5.48
August	70	41	58	43	5.66
September	66	40	55	47	9.39
October	51	32	47	37	20.43
November	41	13	39	32	11.69
December	39	14	35	32	15.84
1911.					
January	37	−6	34	32	4.81
February	39	−10	32	32	2.21
March	45	17	34	32	6.70
April	53	22	37	32	10.15
May	56	37	40	33	5.93
June	65	44	44	35	5.99
Total					104.28

AFOGNAK.

From the 30,725,000 red salmon eggs collected principally during the month of August, 1910, a total of 26,755,000 fry were hatched, a loss of about 12 per cent. The planting of these fry in waters tributary to Afognak Lake continued into June, 1911. From 405,000 humpback eggs taken in August, 1910, plants of 364,150 fry occurred. The average number of eggs per female red salmon for the season as

determined by careful measurement was 2,411. The capacity of the station is approximately 72,000,000 red salmon eggs.

During the summer and fall of 1911 the collection aggregated 30,520,000 red salmon, 6,472,000 humpback, and 224,700 coho eggs. Several million of the red-fish eggs came from the field developed first in 1910 at Malina Lake, which debouches on the side of Afognak Island opposite the Litnik or Afognak catchment basin where the hatchery is located. It is necessary to transport the eggs overland several miles to the hatchery. The Malina fish are said to average larger in size than those running into Afognak Lake.

The cohos do not ripen until so late in the season that egg-taking on an extensive scale is out of the question, owing to the interference of ice. A noteworthy increase occurred this season in the take of humpback eggs. It is proposed hereafter to devote more attention to the propagation of this species of salmon. A station at an appropriate point, particularly in southeastern Alaska, would be a desirable acquisition. The establishment of a substation for red salmon eggs at Eagle Harbor on the south shore of Kodiak Island is under consideration.

A runway was blasted out in the falls of Afognak River, thus making it easier for the fish to ascend. A rack was also built across the river for the purpose of counting the number of salmon entering the lake. It is hoped to establish valuable facts concerning the life history of the salmon by these observations, which are contemplated for a series of years.

An interesting experiment was conducted at the Afognak station last season to determine the degree of ripeness producing the best quality of eggs. The loss on the lot taken from females which were dead ripe—eggs flowing very freely—was less than 1 per cent, while with another lot, where the females were ordinarily ripe upon testing in the usual manner, the loss was about 5 per cent. This shows the need of caution in having fish fully ripe before stripping if the highest degree of efficiency is to be expected.

The Afognak station was built in 1907, and as fry have been planted for only three seasons, it will hardly be time before another year to note any returns as a result of fish-cultural operations at this point. It has been generally conceded that the average life cycle of the salmon is four years, but the idea is gaining ground that it may be five years in the colder northern waters, where development would naturally be slower.

Afognak Island, including Sea Lion Rocks and Sea Otter Island, was set aside as a public reservation for fish-cultural purposes by presidential proclamation of December 24, 1892. Early in 1909 the Bureau gave the natives locally resident permission to take limited numbers of salmon, under the supervision of the station superintend-

ent, for their own use. This appeared to be an equitable recognition of the natives' privileges.

The following regulations governing the reserved waters were established and promulgated March 21, 1912, by the Secretary of Commerce and Labor:

1. No person or persons other than the natives of Afognak Island now resident thereon will be permitted to fish in the reserved waters.

2. Licenses for fishing will be granted to the said natives upon application to the Secretary of Commerce and Labor or such representative of the Department of Commerce and Labor as may from time to time be designated by the Secretary.

3. The kinds and amounts of apparatus to be used, the places where and the manner in which it may be operated, and the time when it may be employed, will be determined by the Secretary of Commerce and Labor and will be subject to changes or modifications from time to time at his discretion.

PRIVATE ESTABLISHMENTS.

FORTMANN HATCHERY.

The largest establishment in the world for hatching salmon is the Fortmann hatchery of the Alaska Packers Association, located some 8 miles from Loring. The capacity of the station is normally reckoned at 110,000,000. The older wing of the hatchery is 24 by 240 feet while the new wing is 32 by 280 feet. There are various smaller buildings for housing the employees and for other needful purposes. All buildings are lighted by electricity, and the hatchery is heated by steam. A well-equipped sawmill is a valuable part of the station's equipment, and a tramway several miles long establishes communication with navigable salt water. A telephone line is maintained to Loring, 8 miles, and thence 22 miles to Ketchikan.

The station is unusually well supplied with water, having four distinct sources, any one of which is sufficient ordinarily, barring accident, to meet all requirements. A pipe line to a series of springs about 3½ miles from the station is the most recent addition to the water-supply system, involving an outlay which has been quite heavy, because the contour of the country made necessary a number of extensive trestles in some places and deep cuts in others. Another supply is received by means of a flume one-half mile long from the creek near the hatchery. A third source is a series of small springs just back of the hatchery, and fourth, a large pump operated by steam draws water from a well near the creek.

A peculiar feature of the arrangement of the hatchery troughs is that they are placed end to end in series 13 and 15 troughs long in the old and new wings of the hatchery, respectively. In other words, the water passing in at the head flows through 13 troughs in the one instance and 15 in the other. Ordinarily, water is not conducted through more than 3 or at the most 4 troughs. The water at the

Fortmann hatchery is clear and as there is a fall of 8 inches between each two troughs for aeration, the eggs are undoubtedly as good at the foot of each long series as at the head, and much less water is required by this arrangement. There are 104 troughs in the old wing and 150 in the new, which at 7 baskets to the trough gives a total of 1,778 baskets. Each basket holds upward of 60,000 eggs, thus making the capacity easily 110,000,000 red-salmon eggs.

The eggs are taken by means of hand pressure, but this pressure is greatly modified, as one of the operator's fingers is inserted in the vent and tears it open for an inch or so. While practically all pressure is thus removed from the eggs, taking by the method of incision would insure further improvement both in quality and quantity. Unless an incision is made it is next to impossible to secure all the eggs, as a number that are fully developed will remain in the folds of the organs unless shaken out, which can be accomplished only by actually taking hold of the parts.

The number of eggs is determined by actual measurement in buckets of carefully determined capacity. Salt has not been used to assist in removing dead eggs. Were it used the crew for picking eggs could be reduced materially. Two nursery ponds each about one-half acre in extent receive the young salmon as they come from the hatchery. Additional nursery ponds have been laid out, also a plankton pond on which construction has been commenced. In the latter it is proposed to develop a growth of plankton to serve as food for the young salmon.

From August 27 to November 6, 1910, a collection of 34,920,000 red-salmon eggs was made. In 1911 fry were liberated therefrom to the extent of 30,245,000 or with a loss of 13.4 per cent, of which 10.64 per cent was on the eggs. All fry were liberated from the nursery ponds into the Naha Stream system.

During the period from August 26 to October 22, 1911, the splendid take of 107,520,000 eggs was made. This is the largest collection of salmon eggs ever taken at a single station. The nearest approach was the collection of 105,450,000 made in 1906, also at the Fortmann hatchery. The remarkably heavy runs in 1906 and again in 1911 afford further grounds for the belief in the 5-year rather than the commonly accepted 4-year cycle of the salmon's return. Additional evidence may be found in the recurrence of the two lightest takes of 22,203,000 in 1903 and 24,465,000 in 1908. The number of males handled this season was 40,425 and the number of females 44,266, giving an average of 2,429 eggs per female. This average is reported as rather low, quite a number of the females being partially spent before being stripped. The average for 1908 was 2,544, for 1909 it was 2,642, and in 1910 it reached 2,746. These averages seem rather low upon comparison with actual counts made this season of the eggs

from a number of specimens. The largest produced 5,362 while the smallest gave 3,203, the average being over 4,000. In view of the small number of specimens examined, these figures are not particularly significant as applied to an entire season's operations. In the light of past records it is improbable that the average of the fish actually stripped throughout an entire season will ever run much over 3,000.

That 1911 has been a very successful season is well set forth in a report from the Alaska Packers Association as follows:

From the results of our season's operations at our Fortmann hatchery it is evident that the Naha Basin is responding to our hatchery's work, as the run of sockeye (red) salmon was larger than ever known in this vicinity. The full capacity of the hatchery was easily filled, and so numerous were the spawning salmon after the hatchery was filled that all the entering streams and lake spawning beds had all the sockeyes that could be massed over them. These spawning salmon even crowded into the flume used for conveying power and entered the ditch carrying the overflow from the nursery ponds. As an example of abundance, one small stream (Fence Creek) where we usually place a fence to hold the spawning salmon and where we generally take about 3,000,000 eggs, this year yielded over 43,000,000 eggs, and after the fence was removed such a large number of salmon entered that every foot of available spawning ground was covered with spawning fish.

The station is in operation throughout the year, the force varying from about 5 to 20 men. It has been roughly estimated that for several months of the season the crew will average one man to 4,000,000 eggs.

KARLUK.

From July 1 to September 15, 1910, the take of red-salmon eggs at Karluk was 49,626,000. During 1910 and 1911 fry were liberated therefrom in Karluk River to the number of 37,722,000, or with the rather heavy loss of 24 per cent. Of this 17.65 per cent represents the loss of eggs, due largely to a shortage of water caused by a break in the supply ditch at a critical stage in the development of the eggs.

From July 1 to October 11, 1911, the collection of eggs was 41,026,800. The number of females stripped was 14,516, and 14,770 males were used. The average number of eggs per female was 2,826.

In the older section of the hatchery erected in 1896 there are 61 hatching troughs containing 292 baskets, which at the rate of 80,000 per basket, makes a capacity of 23,600,000 eggs. In the newer section built in 1903 there are 52 troughs holding 249 baskets, which at the rate of 103,000 makes room for 24,640,000 eggs, or a total capacity of 48,000,000 red-salmon eggs. The troughs in the older section are 1 inch shallower than those in the newer; hence the baskets are elevated about three-fourths of an inch from the bottom by putting blocks at the corners. The dimensions of the baskets are 24 by 14 by 7 inches, the mesh of the wire being three-fourths by one-seventh of an inch.

The hatchery building is well lighted by electricity, power for the generator being derived from a Pelton water wheel. Steam heat is provided. Quarters for the employees are located at one end of and overhead the hatching room. The force varies from 6 or 8 to 15 or 20 men, depending upon the season of the year.

The water supply is conveyed by an open ditch about 1 mile from a series of springs to a most elaborate filtration plant. A small creek near the hatchery also furnishes some water during certain portions of the year.

Brood fish are taken by natives with seines operated in the river below the hatchery. No rack or barrier is erected, thus permitting a good escape up to the natural spawning grounds of Karluk Lake. The stock fish are transferred to two inclosures or corrals; also to a few small ponds to remain until ripening. The corrals are of woven wire, 1½-inch mesh, supported on tripods of 3-inch iron pipe. The corrals are built in semicircular form and measure from 700 to 900 feet around from shore to shore with a maximum depth of about 6 feet. This year the secondary corral was built on the opposite shore instead of just below the main corral as heretofore; it was thought to secure a better bottom and clearer water. Of some 25,000 fish being held in the new corral an estimated number of 20,000 escaped July 13 and passed on upstream to the natural spawning beds. The corrals are normally in fresh water, though they are influenced by high tides.

In addition to the corrals there are 12 ponds in which brood salmon are held while ripening. These ponds are one above another on the side of a slope, and the fish are moved up the hill by means of a gravity system of counterbalanced cars. The ponds range in size from 220 to 1,140 square feet, and all the way from 700 to 1,800 adult fish are put in a pond according to its size. A good supply of water is furnished. Quite a number of fish spawn both in the corrals and ponds. It is estimated that as high as 15 per cent are thus lost from all of the fish handled.

Eggs are taken by incision, but the process is peculiar in that the cut is made forward from the vent to the ventral fins. Quite a number of eggs have thus been left in the fish, but by adopting the better method of a longer incision, extending from the pectoral fins to the vent all eggs will be saved. The placing hereafter of the egg buckets upon a stand or platform independent of that where spawning operations are conducted will do away with the chance for loss as a result of concussion during the tender adhesive period of an hour or so after the eggs are taken. Measurement of the quantity of eggs is made by means of a dipper holding about 4,000 eggs, count being made at frequent intervals to check the average number of eggs con-

tained in the dipper. The baskets, which are deeper than at the other stations, receive from 20 to 25 dippers of eggs each. Instead of being removed by salt the dead eggs are picked out by hand, about 15 men being engaged for this purpose at one period during the past season. The spawning crew is usually made up of 8 men. It is often difficult to get enough good help; the natives are not dependable.

Adjoining the hatchery is a nursery pond about three-fourths of an acre in area and 4 feet deep, supplied by waste water from the hatchery and surplus fresh water from the filtration plant. Practically as soon as the fry hatch they are transferred in buckets to this pond. Also after hatching is over as many fry as possible are held in the troughs until they swim up freely. At the rate of 125,000 to a trough about 7,000,000 fry can be thus held. Last winter over 15,000,000 fry were put in the nursery pond at one time. Ordinarily not more than 5,000,000 get in at a time, for owing to the protracted season the older fry pass out of the pond into the lagoon before the later ones hatch. The fry are spread about the nursery pond as much as possible. They are sometimes fed on canned salmon and a mush made of corn meal. The loss in the pond appears to be very light.

The overflow screens to the pond are usually removed in February, and the young salmon as they swim up work out into the lagoon, which usually remains frozen over from November until May. After the ice breaks up the fry are caught in a live car as they pass out of the pond. This live car is an old skiff with wire mesh-covered ports in the sides and is towed to grounds near the hatchery, where there is a good growth of eelgrass. The ports are then opened and the fry swim out at their leisure. Trout and sculpins no doubt devour quite a number of the young salmon. Last season large numbers of trout were seined near the pond outlet.

There is a tremendous mortality of fish held in the corrals and ponds, due no doubt to crowding so many fish together in a limited space, and the loss is particularly heavy during the latter half of July when the water warms up. The season of 1910, the last for which complete statistics are available, is typical of conditions at Karluk. From June 7 to August 10, 1910, a total of 85,623 adult salmon were impounded. Of these fish a total of 42,174, or nearly 50 per cent, died and were of no use whatsoever. The season's take was 49,626,000 eggs from the remaining salmon, and it is safe to assume, therefore, that a like number, or nearly 50,000,000, were absolutely wasted as a result of the death of fish in the inclosures. It is unfortunate that these fish did not have a chance to reach the natural spawning grounds. Of 200 females selected at random September 12 at Karluk Lake it was found that 197 had spawned clean, 1 contained about

1,000 eggs, while the other 2 each had about 150 eggs which had died with the fish. The need of reform at Karluk is strikingly apparent, and the justification of fish-cultural methods under present conditions is most questionable. The remedy lies in moving the hatchery to the lake, where there will be no need of impounding the salmon. Another argument advanced as a reason for moving the hatchery is that the fry therefrom can be released on the natural spawning grounds of the lake instead of within 2 miles of salt water, as at present. Since it is believed that normally the greater part of the young red salmon remain in fresh water a year before going to sea, it may be assumed that results under the present system of planting at the Karluk hatchery are also of very questionable value. This conclusion is certainly most logical. But irrespective of any loss in this direction there is sufficient actual proof in the enormous loss of eggs due to the death of impounded brood fish to make the removal of the hatchery to the lake an absolute necessity if it is to be operated with satisfactory efficiency.

An exploration was made of Karluk Lake the latter part of July primarily for the purpose of locating a hatchery site. A tributary stream near the lower end of the lake appears to be suitable for this purpose. The lake is about 8 miles long and averages 1 mile in width, but the quite precipitous mountains which almost surround it leave remarkably few tributary streams accessible to the salmon for spawning purposes. The result is that many salmon spawn in the lake along the gravelly beaches. On August 1 the lake contained a large number. Two small lakes drain into Karluk Lake, the outlet of which is Karluk River, a stream shown by compass survey some years ago to be approximately 15 miles long. The present hatchery is about 1¾ miles up from the mouth of the river, to which point it is navigable for a light-draft boat or small launch. Above the hatchery, however, it becomes so swift and shallow in places that only with great difficulty can a light boat be hauled upstream by means of lines from the shore, but there are also stretches where a light skiff can be rowed up without much trouble. To reach the lake it is much easier to go over the old native trail or portage of about 3 miles from the head of Larsen Bay to the river and thence 6 miles up to the lake. A small boat can be rowed most of the way from this point to the lake and can be hauled along shore without much trouble through the mile or so of swift water just below the lake.

The proposed plan of transporting the fry from the Karluk hatchery to the lake for planting is considered impracticable. The removal of the hatchery to the lake would be much more satisfactory. From the foot of the lake to navigable water at the head of Larsen Bay, a distance of some 7 miles in a direct line, the country is open and is

traversed by only one ridge not over 200 feet high. The construction of a tramway would establish an easy line of communication between the lake and salt water.

KLAWAK.

This station is located near the west coast of Prince of Wales Island on Klawak Lake, about 6 miles from the village of Klawak. It is operated jointly by the North Pacific Coast Trading & Packing Co. and the North Alaska Salmon Co.

During the period from August 6 to October 17, 1910, a take of 6,786,500 red salmon eggs was made, from which 6,200,000 fry were planted, beginning in November and continuing into April, 1911. This shows a loss of 586,500 or between 8 and 9 per cent. During the fall of 1911 the total collection of redfish eggs at this point numbered 5,600,000. These figures are based upon a reckoning at the rate of 3,500 per female, but hereafter the quantity of eggs will be actually measured.

The new hatching building erected in 1908 is a substantial single-story structure 24 by 85 feet in size, 12 feet at one end of which is cut off for living quarters. The building is neatly ceiled up both inside and outside with matched lumber and is well lighted. It is heated by means of large stoves; overhead is a loft for storage purposes. The head of the water-supply system is at a dam 2,000 feet from the hatchery. The water is conducted in an almost straight line by means of 1,400 feet of covered flume and 600 feet of wooden pipe. A fall of 16 feet in this distance insures an excellent flow. The water is unusually clear and carries very little sediment.

In the hatchery there are 20 troughs set crosswise of the building, and at 6 baskets to the trough the present maximum capacity is about 8,000,000 red-salmon eggs. There is room, if necessary, to set up several additional troughs and increase the capacity to about 10,000,000. Heretofore eggs have been taken by the method of hand expression, but henceforth the improved method of incision will be employed. The fry are put in buckets and taken to various suitable planting grounds, care being exercised to avoid the mouths of creeks where trout congregate.

The crew consists ordinarily of three persons who are engaged most of the year. Although small, the Klawak station classes with the best in Alaska.

HETTA.

This hatchery is located near the southern end of Prince of Wales Island. From the 9,141,000 redfish eggs taken during the period from August 16 to December 18, 1910, plants of 8,552,500 fry were made, beginning on December 27, 1910, and extending into July, 1911. The loss during the period of incubation was less than 6½ per cent.

The season is unusually long at Hetta, eggs being taken here later than at any other station in Alaska. During the summer and fall of 1911, as the season was dry and only a few fish passed into the lake, the take was small, and numbered but 2,000,000 eggs. Indications point strongly to the conclusion that overfishing of waters contiguous to the mouth of Hetta stream had more to do with the failure to fill the hatchery than low water. Naturally the latter condition caused the fish to loiter longer outside the mouth of the stream than they would had the water been higher.

The hatchery is a gable-roof single-story building of rough lumber 50 feet long and 38 feet wide. At each end is a small shed-like addition containing the heating devices, namely, steel oil drums converted into stoves. Two other buildings for the use of the employees are near by. The hatchery is equipped with 24 troughs of two widths and lengths containing a total of 192 baskets with a capacity of about 11,000,000 red-salmon eggs. The water supply is conducted through a 4-inch wooden pipe about 200 feet long from a small spring-fed creek.

For several years past somewhat old-fashioned methods of operation have prevailed, but beginning with this year a change was inaugurated whereby improvements, including taking by incision, will be adopted. Also the inaccurate and undesirable plan of basing the count of eggs upon the supposed average of 3,500 for each female stripped will be discontinued in favor of actual measurement by dipper.

In planting the fry have been allowed for the most part to pass into a small pond adjacent to the hatchery and thence into the lake. Hereafter more of the fry will be planted about other parts of the lake at suitable points. It is reported that a gill net set off the mouth of the small stream near the hatchery where most of the fry were released caught over 3,000 trout in one season.

Several years ago the plan was tried of feeding fry on "do-overs" from a cannery in the region, but with indifferent success.

The force consists ordinarily of two men, one of whom is engaged practically throughout the year, while one or two others are required for several months.

QUADRA.

At the Quadra Lake hatchery egg-taking commenced August 10 and continued until September 16, 1910, during which time 11,200,000 red-salmon eggs were placed in the baskets. Through the hatching season ending February 16, 1911, there was a loss of 850,000 eggs, or 7½ per cent. Hatching usually begins about 100 days after the eggs are taken.

During the winter 10,350,000 fry were planted in near-by waters, but the release of part of the fry in the two small rearing ponds adjoining the hatchery is of doubtful value, as many are destroyed by trout lying in wait off the mouth of the outlet for the young salmon as they work out into the lake.

For the season of 1911–12, egg-taking began August 24 and by October 2 the hatchery was about filled with a collection of 11,000,000 red-salmon eggs. The largest single day's take recorded in the history of the station occurred September 6, 1911, when 1,122,000 eggs were secured. These computations, however, were based on the assumption that each female produced an average of 3,000 eggs, a method which will henceforth be supplanted by the more modern plan of actual measurement by a receptacle the capacity of which will be determined by actual count. Hereafter, also, the eggs will be taken by the method of incision rather than the obsolete plan of expression by hand. Upon examining a number of females that had been stripped as clean as possible by hand each fish was found upon opening to contain from 100 to 400 good eggs, which might have been removed by means of the abdominal cut in the first place. The taking of the eggs hereafter by the so-called "dry" method—into a pan merely moistened instead of into a pan half filled with water—will also be an improvement.

The hatchery is a single-story structure 81 by 18 feet in size; 12 feet of the building is partitioned off for living quarters. The equipment consists of 30 troughs of two lengths arranged in lengthwise series of 5 troughs each and containing 162 baskets with a maximum capacity of about 12,000,000 red-salmon eggs. The interior arrangement of the hatchery and its equipment are of approved type.

The station is in actual operation some seven months each season, or from about July 15 to February 15. Two men are employed constantly during this period, while a third is engaged during a portion of the season.

ETOLIN ISLAND.

Although Capt. John C. Callbreath's hatchery, on waters tributary to McHenry Inlet, Etolin Island, has been closed since 1906, his plan has been followed of lifting over the dam each season the red salmon endeavoring to ascend to the spawning grounds. During the period from July 22 to September 20, 1911, a total of 2,627 adult salmon were lifted over, this number being made up of 1,487 males and 1,140 females. Over 75,000 red salmon have been thus handled since the beginning of the operation in 1892. A few cohos have also been passed over the barrier, but the less desirable dog and humpback salmon have been carefully excluded. Likewise trout have been kept out so far as possible.

Capt. Callbreath, being a firm believer in the theory that salmon return to the same stream where they are hatched, thought that by artificial propagation and protective measures a heavy run could be built up in a stream attracting normally but a comparatively small number of salmon. He felt that he would have the exclusive preferential right as against other claimants to all salmon produced by his efforts over and above the normal run returning to the stream or for a distance of 2 miles off its mouth. After operating 14 years, failing eyesight compelled Capt. Callbreath to close the hatchery. The fact that no heavy run was established is by no means a reflection on the success of artificial propagation, but indicates instead the fallacy of the parent stream theory, although it is more than probable that the fish return to the same general region where they are hatched.

Mr. Fred Patching, now superintendent of the Fortmann hatchery, states that his observation, based on nine years' experience at the Callbreath hatchery, leads to the conclusion that for every thousand fish which entered from salt water about one million eggs were taken. As many as possible were spawned, but quite a number seemed to disappear.

IMPROVED METHODS OF FISH CULTURE.

Within the last few years there have been noteworthy advances in fish-cultural methods applicable to the propagation of the Pacific salmons. Among the more prominent features is the taking of eggs by the method of incision, also the use of a salt solution in the removal of dead eggs. The value of these and other new methods has been thoroughly demonstrated, and it is only by adopting them that Pacific salmon culture can be brought to the new standard of efficiency. It is the purpose here to direct attention to these requirements and at the same time bring to notice certain precautionary measures and other reforms more or less necessary.

TAKING EGGS BY INCISION.

The long-followed process of taking Pacific salmon eggs by hand expression has been superseded in the last few years by the method of incision, a method discovered and developed by the late Cloudsley Rutter in connection with his study of the life history of the salmon of the Sacramento River. This consists simply of making a cut in the abdominal walls from the throat or near the pectoral fins to the vent, the fish just previously having been killed by a blow on the back of the head. When making the cut the knife is either shielded by a guard or is so held between the thumb and forefinger as to allow not more than half an inch of the blade to project, thus precluding the possibility of injuring any of the eggs. Immediately following the incision the eggs flow in a mass into the spawning pan beneath. The

operator's fingers are inserted into the abdominal cavity gently to assist in removing any eggs that may be enfolded in the organs or that may merely adhere to the walls of the cavity. Fertilization is accomplished in the usual manner.

Care must be exercised not to tear loose from the ovaries any eggs that do not come freely when the organs are moved from side to side by the fingers. Eggs thus torn loose are immature, and if taken it becomes necessary to eliminate them subsequently in the hatchery. It is preferable also to have the fish either in a vertical position or with the head considerably higher than the tail, that gravity may assist the flow of eggs.

It was at first thought necessary—and the practice still obtains at some stations—to bleed the fish either by cutting off the head or tail before making the incision. Experimentation, however, has conclusively demonstrated that no advantage results from this procedure, as the few drops of blood that may occasionally fall into a pan of eggs result in no harm. The extra labor involved in bleeding may therefore be dispensed with entirely.

When taken by the method of incision the eggs are of greatly improved quality; there is no straining or rupture of good eggs as is inevitably the result when heavy hand pressure is exerted; no unripe eggs are torn from the ovaries; and at the same time there is no waste of good eggs left enfolded in the organs, as is certain to be the case in stripping by hand. The improvement in quality is from 5 to 10 per cent and the saving in labor, too, is of noteworthy consideration.

The taking of Pacific salmon eggs by incision marks so distinct an advance in fish culture that it is no longer permissible to continue the obsolete method of stripping by hand.

PREVENTION OF LOSS BY CONCUSSION.

Coincident with the absorptive period in salmon eggs is an adhesive stage varying with the temperature from one to two hours, when the eggs are exceedingly sensitive. This is the so-called period of water hardening. Under no circumstances should the eggs be handled during this stage, nor should they be subjected to the slightest concussion. Repeated tests have demonstrated conclusively that even allowing the buckets containing the eggs to stand on the same platform where spawning operations are being carried on results in considerable loss.

To guard against this, the buckets should either stand on the bottom of the stream or else on a platform in every way independent of and having absolutely no connection with the main platform. To some this may seem like a small and irrelevant consideration, but strict observance is certain to reduce the loss by at least 2 or

3 per cent. During the process of water hardening the buckets should be partly submerged to properly regulate the temperature.

Due caution must be observed not to move the eggs until water hardening is complete. After a little experience the operator can readily tell, upon carefully inserting the hand and finding the eggs free and hard and no longer soft and velvety, even toward the bottom of the bucket, that they may be moved to the hatchery without fear of loss.

EGG COUNTS.

Various methods of measuring quantities of eggs are in vogue, prominent among which is the use of a dipper of a known average egg-capacity determined previously by actual count. Another method is to ascertain by count the average number that will be required to measure up to a mark around the inside of the buckets in which the eggs harden before being placed in the hatching troughs. If the standard for a bucket containing, say, 60,000 eggs is accurately determined and verified from time to time it is even more accurate than the dipper method. The ordinary domestic dipper will not hold much more than 4,000 red-salmon eggs, and as it would be used some 15 times more than a bucket as a unit of measurement the chance for individual variation and error is undoubtedly increased.

It is well established that most fish eggs increase in size not only during the early absorptive period of an hour or so while water hardening, but also throughout the period of incubation. At the Yes Bay station it was found that upon water hardening a quart dipper contained 4,416 red-salmon eggs. Five weeks later but 4,160 of these eggs would go into the same dipper, and at ten weeks of age only 4,000, showing an increase of 10 per cent in size.

To avoid error through any change or variation in the size of eggs all standards of computation ought to be determined by actual count, repeated at frequent intervals. Measurements by water displacement, the von Bayer gauge, or by graduated scales are considered less desirable in their practical application than the common dipper or bucket method before mentioned. Too much caution can not be exercised in the matter of egg counts, for it is only through accuracy as to detail that such data become valuable either to science or economics.

Careful computation of the take of eggs minus subsequent losses is the basis for determining the number of fry released, for it is unsatisfactory and impracticable actually to count the fry other than the very small number which may die between the time of hatching and planting. Error is bound to result if the output of fry is determined by a volume measurement of the eggs just before hatching and using the same standard that was employed near the beginning of the period of incubation.

HANDLING EGGS IN HATCHERY.

At some of the Bureau's stations where salmon eggs are handled it was the custom until a few years ago to "bury" the eggs or leave them undisturbed (aside from picking once the day after spawning) for two or three weeks after putting them in the baskets. The result was that they were in some instances literally buried under and in such a mass of mud and sediment that many eggs were killed. Discontinuance of the practice resulted in a very appreciable improvement.

When the water is so turbid as to cause a heavy deposit of sediment it is better to go over the eggs occasionally, even through the critical stages of development, or until the line of the fish is well formed. Of course the eggs must be handled with utmost caution at all times, but owing to their extreme sensitiveness during the two or three days following the closing of the blastopore and until a perceptible curve shows in the tail, they should be left entirely untouched. It soon becomes easy to determine the stage of an egg's development by holding it up to the light between the thumb and forefinger. In the absence of cautious and skilled operatives and unless the water is roily for an extended period, it is undoubtedly better to let the eggs remain undisturbed until the curvature of the tail is visible to the unaided eye. The accumulation of a moderate coating of sediment which readily washes off is not injurious. In a few instances it has become necessary to handle the eggs during the tender stage to arrest the spread of fungus, but where the water supply is reasonably well adapted to fish-cultural purposes such a course is rarely if ever necessary.

REMOVAL OF DEAD EGGS BY THE USE OF SALT SOLUTION.

Among the most noteworthy advances in fish-cultural methods during the last few years has been the use of salt as an aid in the removal of dead eggs. The development of this process has extended over a period of several years, but it is more during the last year or so through the efforts of Mr. L. E. Baldridge, of the Yes Bay station, that it has reached a high degree of efficiency.

Compared with the time-honored process of picking by hand there are marked advantages in using the salt solution, and chief among these is the great saving of labor. It is estimated that if the eggs happen to be of not more than mediocre quality it would take at least 20 pickers to remove as many dead eggs as could 2 men using the salt solution. Moreover, the operation is much more thoroughly performed in the latter process than is possible in picking by hand.

Another advantage of using the solution is that it is possible thoroughly to clean the eggs. This greatly reduces any loss through

contamination and infection resulting from the decomposition and fungus growths which inevitably follow the long-continued presence of dead eggs that in the hand-picking method frequently escape attention. Even when utmost care is taken to pick out all dead eggs, fungused masses will occasionally appear. This condition is rarely observed when the salt solution has been used, and it undoubtedly means that in the aggregate many eggs are saved. Still another point in favor of the solution, it is generally believed, is that it acts as a tonic or stimulant to the good eggs while at the same time as a deterrent to the growth of fungus. Again, in picking by hand there is apt to be loss by movement of the eggs during delicate stages of development; and the oft-repeated insertion of egg tweezers, which are bound to touch other eggs, undoubtedly at times results in injury.

Recent experience has demonstrated that the solution may be applied effectively to eggs freshly taken as well as those in more advanced stages of development.

The principle of the salt bath is simply that the specific gravity of the good eggs is greater than that of the bad eggs, hence upon being placed in the salt solution the good eggs sink and the bad remain afloat and are easily removed. It is vitally essential to the success of the undertaking that the solution be of the proper strength, and it is for this reason that the beginner is apt to become discouraged. If the solution is too weak all the eggs, both good and bad, will sink, while if it is too strong all will remain afloat. The margin of the proper density is so narrow that in the operation it is necessary every few minutes to strengthen the solution by adding more salt or brine, otherwise the small amount of fresh water which adheres to a basket of eggs as it is lifted from the hatching trough into the solution will affect unfavorably the results when treating succeeding baskets. Experience and careful observation, however, will soon make it possible for the operator accurately to judge when to add a bit of the stock solution. It is a convenience, of course, to have a salinometer at hand when preparing the solution. It is commonly the practice as an aid in preparing the solution to test it occasionally with a few eggs.

Highly successful results in using the solution with red-salmon eggs have been attained at the Yes Bay station, and a detailed description is accordingly given of the methods pursued at that place:

The chief item of equipment consists of a water-tight wooden tank, 4 feet long, 2½ feet wide, and 10 inches deep, for holding the solution in which the eggs are immersed. Before each basket is immersed it is necessary that the surface of the solution be perfectly quiet, for any ripple or current will tend to disturb the buoyant effect of the solution upon the eggs. Therefore it was found of great convenience last winter to use a floating frame made of half-inch material 6 inches

wide fastened together vertically and at right angles, thus forming open squares about 6 inches either way. After each basket of eggs is lifted from the salt bath this frame is placed in the solution to stop all motion of the water, being pushed down until it is almost submerged and held firmly against the side of the tank for a few seconds. Upon being carefully withdrawn the solution is quiet and the next basket of eggs may be immersed without further delay.

Another piece of equipment is a feather fan with which gently to push the floating dead eggs away from over the submerged basket into which the good eggs have settled. Unless the dead eggs are quickly moved they too will sink. A feather fan made by fastening eagle feathers to a thin strip 8 inches long by 1½ inches wide works much more satisfactorily for this purpose than a wing. An ordinary hand scaff net about 12 by 14 inches in size for removing dead eggs from the tank, a dipper, and a bucket complete the outfit. Wood and metal surfaces in all equipment should be well coated with asphaltum or some similar preparation.

At Yes Bay as soon as five or ten million eggs are far enough advanced to stand light concussion the baskets are lifted out of the troughs and the eggs are stirred thoroughly with the hand, which causes practically all of the unfertile or empty eggs to turn white. As soon as the line of the fish shows plainly when held up to the light and there is a distinct curvature to the tail, the eggs are sufficiently well advanced in development to stand stirring. After this process the baskets are returned to the troughs and allowed to remain three days, for when first turned the unfertile eggs are about as heavy as the good eggs and consequently would sink if the salt solution were applied at once.

On the fourth day after stirring, everything being in readiness, five or six baskets are removed from a trough and set on top to drain. After a few moments a basket is grasped at each end and is lowered into the tank containing the solution until the liquid comes through the eggs. A light shake is then given to level up the eggs in the basket. Next, slowly and very gently, the basket is lowered until the brine comes almost to its rim and is held perfectly still for a moment. All the eggs in the basket will rise, but soon the good eggs will begin to sink, and presently, if it is a basket of poor eggs, the surface will be completely covered with bad eggs. Now, without the slightest jar, the basket is lowered far enough below the surface to permit an egg to float over the rim. The bad eggs will immediately start toward the edges of the tank. After a few seconds the basket is gently lowered until it rests upon the bottom. The remaining dead eggs are then brushed away from over the basket by means of quick, short, and light strokes of the feather fan; long, sweeping strokes are to be carefully avoided. One end of the basket is then gently raised until it is above

the surface of the brine and the basket is drawn toward the end of the tank and out from under the floating dead eggs. At the same time the fan is used with the other hand to aid in moving any of these floating eggs to one side. The fan is then dropped and the lower end of the basket is grasped and the whole is quickly raised out of the solution. The basket is set at an angle on the tank for a moment to drain and is then carried to the hatching trough. The attendant lifts out another basket to drain along with the four or five others originally removed and returns to the tank of brine with the basket that has been draining the longest.

While this is being done the other operator skims the dead eggs off the surface of the brine and places the frame described above in the tank for a moment to stop all motion of the solution. After five or six baskets have been treated, any eggs that have settled to the bottom of the tank are removed, as they absorb and weaken the brine. It is necessary, as earlier mentioned, to add a little fresh brine after handling each basket. The eggs should be as clean as possible, as the solution will not be effective when it contains much sediment. A 1-inch hole with plug in one corner of the tank is convenient for drawing off any deposit of this character. Should failure occur in treating a basket of eggs, as, for example, if by sudden jar they are all caused to sink, or if the brine is too weak or too strong, the basket must be put back in the hatching trough, as it will not respond to treatment again the same day.

At Yes Bay last winter a large portion of the 72,000,000 eggs were thoroughly cleaned up at one handling. Two men ran as many as 10,000,000 eggs through the salt bath in a single day. It is customary on the day after treating the eggs to have them gone over, so that if any dead eggs remain they may be picked out by hand. This, however, requires very little time, as but few dead eggs are found. No alarm need be felt if the eggs seem to shrink as a result of the immersion, for they will soon resume their normal size upon being replaced in fresh water.

The use of the salt solution has been extended lately to the handling of lake-trout eggs in Michigan and Minnesota, and there appears to be no reason why it is not equally well adapted to the eggs of other salmonoids. Certainly its many advantages commend further experimentation in this direction.

PLANTING.

Although good judgment and foresight are usually displayed by the fish culturist in the manner of taking and handling fish eggs, there is often a decided tendency to neglect in the planting process. The desire to make a good showing as regards numbers in the hatchery output is commendable, but paramount to this is always the real

object and purpose of fish-cultural operations, viz, to increase the productivity of the waters. No matter how thorough the work in the hatchery proper may be, no adequate or justifiable return can be expected unless every possible precaution is likewise taken to conclude the process properly. There is no justification whatever for artificial or, perhaps, as it may be termed "protected," propagation where the returns to the waters are not made in the most scientific and intelligent manner possible. Otherwise it were better to let nature do the work.

Especially is there lack of consideration as to the proper age at which to plant young fish, and again as to the selection of places for releasing them in order to give the best results.

With the means ordinarily at command the best results are obtained by planting young red salmon when the umbilical sac is about two-thirds absorbed, which is the time when the fry begin to swim up freely. It may sometimes be necessary to plant before the sac is sufficiently absorbed in order to relieve a congested condition in the hatchery, for fry require much more trough space than eggs; but so far as possible the planting of fry before the sac is two-thirds absorbed is to be guarded against. With the temperatures prevailing at the Alaska hatcheries this means that the fry must be held at least four or five weeks after hatching. Fry take food some time before the sac is entirely absorbed, the desire to eat being first apparent to a noticeable degree about the time they begin to swim up freely.

Usually the best planting grounds are rocky places and areas more or less covered with vegetable growths, where the young fish may be scattered to give them all the protection possible from predatory fish and other natural enemies and at the same time afford an adequate supply of natural food.

It is better ordinarily to take the fish out and plant them than to allow them to pass of their own free will into the pond outlet and thence to the stream or lake, for in the latter event the school of trout and sculpins collected at the outlet where the young salmon leave the protection of the pond is certain to cause much loss. If possible, it is well to plant the fish in roily water, thus making it difficult for trout and other enemies to observe and devour them. In the planting of chinook salmon in California it has been the practice upon various occasions to shovel in clay or other earth at a point near where the fry were being planted, thus to create an artificial turbidity.

In Alaska the plan of seining or netting schools of trout from the vicinity of the salmon planting grounds is a worthy practice. The trout are of no value in the region save occasionally when used by natives, and their destruction works as a distinct benefit to the salmon industry. It has been found of advantage at some hatcheries

to construct wire corrals about the mouths of the streams wherein the young salmon have been released, in order to exclude the trout.

In the absence of localities suitable for fry planting it is desirable to rear the fry until they have acquired a degree of activity and strength which will better enable them to cope with their natural enemies or other unfavorable conditions.

The feeding of fry upon herring roe, canned salmon, uncooked fish, and other animal foods has been practiced with varying degrees of success for many years. Both hatching troughs and nursery ponds have been employed for handling the fish. The capacity of the troughs, however, is greatly reduced for young fish as compared with eggs; hence if extensive rearing operations are contemplated it is necessary to have a large number of additional fry troughs, or, better still, a series of rearing or nursery ponds. To produce the best results, nursery ponds should be of limited area, say, 20 feet by 40 feet, thus permitting a control over the fish impossible in large ponds. At one station there is a rearing pond nearly an acre in extent, but its efficiency is much impaired for the reason that the fish do not get the amount of food they require. The food is scattered about the edges, but many of the fish toward the center of the pond obtain little or none of it. In view of the unequal rate of growth considerable loss from cannibalism is bound to result in a pond of this character. Smaller ponds permit of a control over the fish impossible in larger ponds.

In the rearing of young salmon it would theoretically be of advantage to create a growth of minute natural life in the water to afford a supply of food. Taking into consideration, however, the large scale upon which hatching is conducted in Alaska, the idea is of doubtful value, because of the difficulty of producing enough of this food to supply the needs of more than a few salmon. Starvation and cannibalism menace the undertaking. As an aid to or in combination with artificial foods such a plankton growth appears to be very desirable. Further experimentation is necessary, however, before definite conclusions as to the practical value of plankton as food for salmon can be determined. At the Fortmann hatchery of the Alaska Packers Association some preliminary work has been accomplished in this field.

It can not be too strongly urged upon all engaged in fish-cultural operations that it is as highly essential to exercise caution and pursue an intelligent study of conditions in planting the fish as it is to devote care to eggs and fry prior to the time of planting.

FUR-SEAL SERVICE IN 1911.

By Walter I. Lembkey,
Agent in charge.

The season of 1911 was the second during which the Bureau of Fisheries, acting directly for the Government and depending solely upon its own resources, has successfully conducted the business of taking fur-seal skins on the Pribilof Islands, the handling of the various business problems connected therewith, and the care of the native inhabitants. Whatever doubt may have existed regarding the ability of this Government to conduct for itself the taking and marketing of sealskins, thereby eliminating the lessee operating under a royalty, all such questions may be considered as disposed of by the successful performance of these functions by the Bureau during the past two years. During this period at least as high a standard of efficiency was maintained as during that of the two leases.

SUPPLIES FOR THE ISLANDS.

The agent, who had spent the winter in Washington, arrived in San Francisco on April 20, 1911, and at once began purchasing the food, clothing, and other supplies needed for the islands. The steamer *Homer*, which had been chartered for the season of 1910, was again chartered for the season of 1911 on the same terms as in the previous year.

The Department has been furnished with the various inventories of merchandise and reports showing the transactions attending purchase of supplies and the sale of merchandise to the natives and others.

The system of accounting adopted July 1, 1911, is sufficient, it is believed, to trace every item of goods disposed of. Duplicate cash slips are made for every cash sale, the originals of which are sent to the Department. Every article of merchandise, whether sold to a native against his credit for wages or used for the upkeep of the stations, is likewise recorded on duplicate slips, the originals of which are forwarded to the Department at the close of the year. Transactions of all descriptions are recorded in a double-entry system of books, from which a trial balance is taken monthly. The cash is balanced daily in the summer season and two or three times a week during the winter, when the store is open only at intervals.

DEATH OF DR. CHICHESTER AND DR. HAHN.

On May 31, 1911, a distressing accident occurred on St. Paul Island. Dr. Harry D. Chichester, assistant agent, and Dr. Walter L. Hahn, the naturalist on the seal islands, with their wives and a native, Neon Tetof, while sailing on the lagoon were unable to put about successfully in the high wind and by the capsizing of their boat were exposed to the ice-cold water for more than an hour. All were alive when rescued, and Mrs. Chichester and Mrs. Hahn, by the diligent efforts of the physician, were resuscitated. The native also survived, but Dr. Chichester and Dr. Hahn, necessarily left without medical attention for a time, succumbed to the effects of the exposure.

In this tragic event the fur-seal service has lost two of its most able and valuable employees. In addition to looking after all business and administrative affairs of the island during the preceding winter, Dr. Chichester had entered upon a careful study of the sanitary and health conditions on the islands, having graduated in medicine in the preceding spring and during his medical course given special attention to those diseases, such as pulmonary affections, which are most prevalent among the Aleuts. These studies and his intimate knowledge of the conditions on the seal islands led him to believe that all infectious diseases can be completely eradicated in those restricted localities, and, inspired by this ambition and hope, he entered vigorously upon the securing of the vital and statistical data necessary to enable him to formulate a definite method of procedure. The progress he had made was so encouraging as to induce the belief that had he lived Dr. Chichester would have realized his ambition completely. Unquestionably he would have been able greatly to improve the health conditions on the Pribilofs.

Dr. Hahn entered upon his duties as naturalist in the fall of 1910. His training, wide field experience, and well-known ability and enthusiasm as a zoologist and practical business man were assurance that his appointment to the position of naturalist, just established, would prove a wise selection. His report, written up to the very day of his death, shows that he possessed a remarkably clear understanding of the problems with which he had to deal. Arriving at the islands August 23, 1910, he made daily observation and study of the seals and foxes throughout the fall, winter, and spring. He also gave attention to the birds and other animals on and about the islands, to the plants, and to meteorological phenomena, and gave much thought to the local educational problems and the intellectual and moral well-being of the natives, working out a system of education such as he believed best adapted to their needs.

DEFICIENCY IN PERSONNEL.

Never before was the fur-seal service so handicapped as to employees as in the summer of 1911. Deprived by death of two of the most important of its members, it was still further depleted by the unfortunate illness of Dr. Pedro A. de Figaniere and the pressing private affairs of Dr. Norman P. Morgan and one of the school teachers, Mr. Ned B. Campbell, compelling all three to leave on the first return trip of the supply vessel, which carried also the storekeeper, Mr. A. H. Proctor, who was required to go to San Francisco to purchase supplies for the second trip of the *Homer*. In the absence of six of the small working force, the islands were thus left with only Agents Lembkey and Judge and one school teacher, Simeon A. Melovidov, on St. Paul, with Agent Clark and Dr. H. C. Mills on St. George. There was no physician on St. Paul during the summer.

Notwithstanding this handicap, the work on the islands progressed satisfactorily, although the activities of those present were, of necessity, confined to the carrying forward of work which was imperative. The reserving of young male seals, the killing of the surplus males, the curing and shipment of skins, the sale of merchandise and the accounting for the cash were the important duties and were carefully attended to. It is regretted that the limited force on the islands did not allow the usual detailed observations and the various minor enumerations of seal life to be made.

AFFAIRS OF THE NATIVES.

BANK ACCOUNTS.

With the expiration of the contract of the North American Commercial Co. in 1910, it became necessary for the Government to look after the savings accounts of the natives, which previously had been handled by the company. Drafts were issued by the company to the natives except where the amounts did not exceed $25, in which event settlement was made in cash. The natives turned the drafts over to Agent Lembkey who, duly clothed with power of attorney, acted as their trustee and opened savings accounts with the Union Trust Co. at San Francisco. These accounts draw interest at the rate of 3½ per cent per annum.

As stated in the report of the seal fisheries for 1910, the savings of the St. George natives, amounting to $1,055.35, could not be deposited because through an oversight the drafts had not been indorsed. At the first opportunity in the spring of 1911 the drafts were taken back to St. George and after indorsement were returned and deposited with the Union Trust Co. In the meantime the North American Commercial Co. had protected the drafts by a deposit of the full amount thereof.

In the spring of 1911 the interest on the St. Paul accounts was collected, taken to the islands, and paid to the proper persons. At the bank's request, the interest was collected only to January 1, 1911, in order that thereafter the interest may be drawn in conformity with the bank's rule to pay interest January 1 and June 30 of each year.

The payments of interest to the St. Paul natives, as shown by re-receipts in the possession of Agent Lembkey, were as follows:

Parascovia Kozlof	$1.09
Peter Bourdukofsky	.94
Elizabeth Rookavishnikof	.29
Alexander Melovidov	1.70
Catherine Krukof, guardian of Alexai Emanof	1.67
Alexander Merculief	1.23
Nekita Hopof	.36
Akalina Fratis	3.10
Agrafina Fratis	.51
Agrafina S. Pankoff	2.07
Peter Oustigof	1.02
Julia B. Krukof	1.23
John Stepetin, guardian of Marina Stepetin	.29
Lukiria Galaktionef, guardian of John Hansen	$2.69
Apollon Bourdukofsky	1.47
Akalina Fratis, guardian of Martha Fratis	.51
Akalina Fratis, guardian of Ouliana Fratis	.51
Akalina Fratis, guardian of Simeon Fratis	.51
Ouliana Gromof, guardian of Tekan Volkof	7.03
Nicoli Bogadanof, guardian of Agrafina Bogadanof	1.16
Total	29.38

In addition, a deposit of $50 was made to the account of Simeon Fratis, representing savings from his seal division. Payments were made of $20 from the account of Julia B. Krukof, at her request, and of $40 from the account of Lukiria Galaktionef, guardian of John Hansen, to defray the expense of sending the latter to the Chemawa Indian School.

A list of the accounts, including the one deposit and two withdrawals named above, is as follows:

St. George Island:	
Fevronia Galanin	$40.00
Dimitri Lestenkof	137.00
Michael Lestenkof	240.00
Peter Prokopiof	83.55
Emanuel Zaharof	33.20
Zoya Swetzof	123.00
Mary Galanin	245.00
Michael Shane	63.55
Mary Philamonof	90.05
Total	1,055.35
St. Paul Island:	
Alexander Merculief	170.00
Nekita Hopof	50.00
Agrafina Bogadanof	161.10
Marina Stepetin	40.00
Apollon Bourdukofsky	203.30
Parascovia Kozlof	150.00
St. Paul Island—Continued.	
Peter Bourdukofsky	$130.00
Elizabeth Rookavishnikof	40.00
Agrafina Fratis	71.00
Agrafina S. Pankof	285.00
Peter Oustigof	140.00
Alexander Melovidov	235.00
Julia B. Krukof	150.00
Simeon Fratis	121.00
Akalina Fratis	426.00
Alexai Emanof	230.00
Tekan Volkof	966.00
Martha Fratis	71.00
John Hansen	330.00
Oulianna Fratis	71.00
Total	4,040.40
Grand total	5,095.75

RESOURCES FOR NATIVES' SUPPORT.

The instructions of the Department required that the amount which the natives should receive for the taking of fox skins on St. George and sealskins on both islands in 1911 should be approximately $35,000. The rate at which they were to be paid for sealskins to realize this sum was to be fixed after the season's catch on the islands had been ascertained.

Under this instruction a rate of $2.90 was fixed for the 12,008 skins in the salt houses, the amount thus being $34,823.20. This sum, together with the $1,195 paid for taking 239 blue foxes and $1 for 1 white fox on St. George, aggregated $36,019.20 available for natives' support. From this was deducted $4,734.05 for coal used on both islands.

Following is a statement of the amounts earned by the natives, to be applied to their support:

St. Paul:	
9,560 sealskins, at $2.90	$27,724.00
St. George:	
239 blue foxes, at $5; 1 white fox, at $1	1,196.00
2,448 sealskins, at $2.90	7,099.20
Gross resources	36,019.20
Deduction of coal for both islands:	
365 tons, at $12.97	4,734.05
Net amount available for natives' support	31,285.15

The allotment of this fund is as follows:

St. Paul:	
Weekly issues of supplies	$16,329.40
Surplus	4,336.79
St. George:	
Weekly issues of supplies	8,418.96
Surplus	2,200.00
	31,285.15

The amounts allotted for weekly supplies for both islands are based upon a per capita consideration of the native population. The weekly allowance for each family is computed upon the number of persons in each family and upon the idea that the larger family should receive more than a smaller family.

At the rate of weekly issue adopted there should be an unexpended balance of the fund apportioned for each island at the close of the year. It is the intention to distribute this balance, whatever it may be, in cash to those instrumental in earning the fund, the first-class men to receive a larger share of the balance than the second-class men, and so on.

If at the end of each month an unexpended balance of a family's allotment for provisions and clothing is found and the native desires to take this unexpended balance in cash, he may do so at the end of each month. This is in addition to any cash the sealer may receive from the undivided surplus expected to accrue at the end of the year.

The idea of cash payments is to encourage economy and thrift in the purchase of supplies. The native is invited to save such amounts of cash as he can, to be used either to open a bank account or to purchase articles of comfort or use other than the necessaries of life.

CENSUS OF NATIVE INHABITANTS.

The census taken June 30, 1911, showed 190 resident natives on St. Paul and 99 on St. George, or a total of 289. This is the same total shown by the previous annual census, for while there was a net decrease of 8 on St. Paul there was a like increase on St. George.

The following is an abstract of the 1911 detailed census statement filed at the Bureau of Fisheries in Washington:

POPULATION OF PRIBILOF ISLANDS JUNE 30, 1911.

	St. Paul.	St. George.	Total.
Number present	190	99	289
Number males	91	48	139
Number females	99	51	150
Deaths	18	1	19
Births	13	7	20
Arrivals	1	2	3
Departures	4		4
Decrease	8		8
Increase		8	8

MANAGEMENT OF THE SEAL HERD.

MARKING OF BACHELORS FOR BREEDING RESERVE.

Under instructions from the Bureau the practice of marking bachelor seals to form a breeding reserve of male seals, which was begun in 1904, was continued through the season of 1911. As directed, 1,000 3-year-old males were selected for this purpose, 800 being obtained on St. Paul and 200 on St. George. The following is a list of the drives and the number marked in each:

THREE-YEAR-OLD MALE SEALS MARKED FOR BREEDING RESERVE, 1911.

Date.	Rookery.	Number.
	St. Paul:	
July 1	Reef	361
3	Northeast Point	264
	Polavina	48
4	Zapadni	107
5	Reef	20
	Total, St. Paul	800
	St. George:	
June 24	Staraya Artel	30
	North	30
29	Do	62
30	Staraya Artel	7
July 3	North and East	36
7	East, North, and Staraya Artel	35
	Total, St. George	200
	Grand total	1,000

These young males were marked in the usual way, namely, by clipping from the top of their heads with sheepshears a round patch of fur, making a mark which can be distinguished by the clubbers when these seals afterwards appear in the drives and which, of course, deters the clubbers from striking them. The mark lasts only during the season in which it is made and disappears at first shedding thereafter.

The temporary character of this mark placed upon young seals reserved to become eventually breeding bulls has occasioned some criticism to the effect that, as the mark disappears entirely within a year, there is no assurance that these young seals, reserved in one year, are not killed by the clubbers in the year following. It may be stated that this matter has been carefully considered on the islands and every effort has been made to devise some method whereby a permanent brand might be placed on the animals selected which would prevent the seal from being clubbed and at the same time offer no difficulty in its application to the animal.

KILLING OF SEALS.

SKINS SHIPPED.

During the sealing season ended August 10, 1911, and including the seals killed for food during the fall of 1910 and spring of 1911, as well as the regular killing season of 1911, there were taken on both islands 12,006 skins, of which St. Paul furnished 9,558 and St. George 2,448. These skins were shipped on the *Homer* to San Francisco, the vessel arriving there September 9, were taken at once to Oakland Long Wharf, and thence, packed in barrels, were shipped on September 13, in ventilated freight cars, to New York and by steamer to London, England, where they were sold.

NUMBER OF DRIVES.

On St. Paul seven drives were made to furnish the natives with food during this period. These, together with 4 skins taken from Japanese prisoners, 2 skins found in a bidarra (or skin lighter) after last year's shipment had been made, and 53 skins taken by watchmen and fox hunters, amounted to 1,275 skins. Another food drive, August 10, 1911, yielded 407 skins, bringing the total from food drives to 1,682.

During the regular killing season which began July 1 and ended July 31, 1911, 26 drives were made, from which 7,878 skins were secured.

The skins obtained in the manner above described numbered 9,560, and it was presumed that this number would be available for shipment. When, however, the skins were taken out of salt, bundled, and counted finally, the total lacked two skins of the number counted into the salt. These presumably were buried in the tons of salt contained in the salt houses and undoubtedly will appear when this salt is again moved in the spring. The number shipped, therefore, was 9,558 instead of 9,560 shown by the record to be in salt.

On St. George, 500 skins were taken during the food-killing season in 8 drives. This number also includes 17 skins taken at various times by watchmen for food. During the regular sealing season 14 drives were made, which, with 6 skins taken by watchmen, afforded 1,948 skins. The whole number of skins secured on St. George from food killings and regular drives was 2,448, all of which were shipped.

DETAILED STATISTICS OF DRIVES.

Following are tabulated statistics of the killing of seals during the regular season of July 1 to 31, 1911, and in one food drive August 10 of that year. The drives made for food during the fall of 1910 and spring of 1911 either were so mixed with females that no record of dismissals was made or the drives were on Sea Lion Rock, where the escaping seals can not be controlled or counted. Also in small killings at Zapadni and Staraya Artel on St. George during the regular season, made by the natives and aggregating 72 skins, no record of dismissals was made. These drives are therefore omitted from the table, and the totals are correspondingly less than the number of sealskins shipped.

STATISTICS OF DRIVES BEGINNING JULY 1, 1911.

Date.	Rookery.	Seals killed.	Dismissed.			Seals in each drive.	Per cent killed.
			Branded.	Small.	Large.		
	St. Paul Island:						
July 1	Reef	330		53	63	446	74
3	Northeast Point	315		42	71	428	73
3	Polavina	12			31	43	27
4	Zapadni	112		20	38	170	65
5	Reef	392	82	85	73	632	62
5	Tolstoi	240	16	58	50	364	65
8	Northeast Point	340	129	47	54	570	59
10	Zapadni	298	29	38	30	395	75
11	Reef	405	47	22	16	490	82
11	Tolstoi	73	4	3	5	85	85
14	Northeast Point	597	23	29	33	682	87
16	Reef and Gorbatch	481	24	26	25	556	86
16	Tolstoi	280	7	6	7	300	90
19	Northeast Point	398	21	37	31	487	81
21	Reef	435	34	47	29	545	79
21	Tolstoi	78	4	10	12	104	75
22	Zapadni	318	14	60	31	423	75
24	Northeast Point	327	31	46	16	420	78
26	Reef and Gorbatch	573	62	33	77	745	76
26	Tolstoi	186	12	11	57	266	69
27	Zapadni	251	22	19	42	334	75
29	Polavina	20	9	6	22	57	35
30	Northeast Point	713	94	83	96	986	72
31	Reef and Gorbatch	880	64	31	43	1,018	86
31	Tolstoi	120	11		26	157	76
31	Zapadni	111	18	3	10	142	78
Aug. 10	Reef and Gorbatch	407	5	76	6	494	82
	Total, St. Paul	8,692					
	St. George Island:						
June 19	North	68		8	31	107	63
July 3	East, North, and Staraya Artel	266	86	25	18	395	67
7	do	165	81	18	11	275	60
11	do	172	18	8	8	206	83
15	do	214	27	13	3	257	83
18	do	13	3			16	81
21	do	176	9	16	1	202	82
25	do	323	40	15	18	396	81
28	do	161	13	10	9	193	83
31	do	312	34	23	18	387	80
	Total, St. George	1,870					
	Total	10,562					

WEIGHTS OF SEALSKINS TAKEN.

Of the 9,558 sealskins shipped from St. Paul, 9,285 appear in the following table. All skins taken were weighed, with the exception of 162, represented by the 4 taken from prisoners, 2 found in the bidarra after last year's shipment, 53 taken by watchmen for food, and 103 taken this spring on Sea Lion Rock after Agent Chichester's death and before the arrival of the supply ship. The weights of the remaining 111 skins not appearing in the table were omitted inadvertently while being recorded at the salt house and transcribed into the office record.

On St. George all skins taken were weighed and the weights are given in the subjoined table.

WEIGHTS OF SEALSKINS TAKEN ON THE PRIBILOF ISLANDS, ALASKA, DURING THE YEAR ENDED AUGUST 10, 1911.

Weights.	St. Paul Island.	St. George Island.	Total.	Weights.	St. Paul Island.	St. George Island.	Total.
Pounds.	*No. skins.*	*No. skins.*	*No. skins.*	*Pounds.*	*No. skins.*	*No. skins.*	*No. skins.*
4	1	....	1	$7\frac{1}{4}$	409	129	538
$4\frac{1}{4}$	3	....	3	$7\frac{1}{2}$	425	118	543
$4\frac{1}{2}$	4	2	6	$7\frac{3}{4}$	310	53	363
$4\frac{3}{4}$	11	3	14	8	363	42	405
5	833	72	905	$8\frac{1}{4}$	102	22	124
$5\frac{1}{4}$	605	103	708	$8\frac{1}{2}$	74	8	82
$5\frac{1}{2}$	855	194	1,049	$8\frac{3}{4}$	12	....	12
$5\frac{3}{4}$	906	244	1,150	9	5	....	5
6	1,220	324	1,544	$9\frac{1}{4}$	2	....	2
$6\frac{1}{4}$	634	300	934	$9\frac{1}{2}$	....	1	1
$6\frac{1}{2}$	752	355	1,107				
$6\frac{3}{4}$	798	232	1,030	Total	9,285	2,448	11,733
7	961	246	1,207				

ENUMERATION OF THE HERD.

COUNTS OF BULLS.

At the height of the season of 1911, which occurred about July 15, careful counts were made on both islands, with exception of Sea Lion Rock, of all breeding bulls with harems as well as idle bulls and quitters. Those counts for both islands follow:

COUNT OF BULLS WITH HAREMS, IDLE BULLS, AND QUITTERS, 1911.

Date.	Rookery.	Bulls with harems.	Idle bulls.	Quitters.
	St. Paul Island:			
July 13	Polavina	42	10	3
13	Polavina Cliffs	23	4	2
13	Little Polavina	10	3	4
14	Northeast Point	257	38	21
14	Amphitheatre	8	....	2
14	Ketovi	53	7	3
14	Lukanin	31	5	6
14	Lagoon	10	1	....
14	Tolstoi	71	10	3
14	Tolstoi Cliffs	27	4	1
15	Little Zapadni	60	6	14
15	Zapadni Reef	4	....	....
15	Zapadni	113	17	22
16	Gorbatch Cliffs	2	....	2
16	Gorbatch	108	10	11
16	Reef	215	39	3
16	Ardiguen	11	1	....
	Total	1,045	155	97
	Sea Lion Rock (estimated)	45	6	....
	St. George Island:			
13	North	105	21	....
13	Staraya Artel	36	12	....
14	East Cliffs	54	15	....
14	East Reef	21	6	....
14	Little East	3	....	....
14	Zapadni	47	17	....
	Total	266	71	....
	Grand total	1,356	232	97

ESTIMATED SUMMARY OF SEAL LIFE IN 1911.

Owing to the fact that the pelagic sealers were unusually active during the summer of 1911 it was deemed inadvisable to attempt an actual enumeration of the herd. The following figures, based upon previous censuses and estimates and upon such actual counts as were made in 1911, are believed to be as close an approximation to the size of the herd as it is now possible to make.

Bulls, active	1,356
Bulls, idle	329
Half-bulls	2,200
Bachelors, 3-year-old	1,200
Bachelors, 2-year-old	2,897
Bachelors, yearling	10,944
Male pups	20,740
Breeding females	41,480
Two-year-old females	10,770
Yearling females	10,944
Female pups	20,740
Total	123,600

CONDITION AND EXTENT OF THE NATURAL OYSTER BEDS AND BARREN BOTTOMS OF MISSISSIPPI SOUND, ALABAMA

By H. F. Moore
Assistant in Charge of Scientific Inquiry

Bureau of Fisheries Document No. 769

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CONDITION AND EXTENT OF THE NATURAL OYSTER BEDS AND BARREN BOTTOMS OF MISSISSIPPI SOUND, ALA.

By H. F. Moore,
Assistant in Charge of Scientific Inquiry.

INTRODUCTION.

At the request of the Alabama Oyster Commission, through its president, Mr. John Craft, and on the representations of the several Senators and Representatives in Congress from that State, the Bureau in February, 1910, made a preliminary examination of the oyster-producing regions of Mobile Bay and Mississippi Sound. It appeared from this examination that the oyster interests were of sufficient present and prospective importance to warrant a survey and report on the productive and barren bottoms of Mississippi Sound.

The triangulation of the region was begun by the Coast and Geodetic Survey, under an arrangement for cooperation between the two bureaus, during the summer of 1910, and was maintained so far in advance of the requirements of the biological and hydrographic work of the Bureau of Fisheries that the latter never suffered a moment's delay for lack of triangulation points.

Although the work performed by the Coast and Geodetic Survey in connection with this investigation is of a character not requiring treatment in the text of this report, the State authorities charged with the administration of the oyster laws should appreciate it as that part of the results which has the most enduring value. The accurately determined and substantially marked stations furnish to the State an invaluable and permanent basis for the survey and delimitation of leaseholds of barren bottom for purposes of oyster culture, and if properly used will enable Alabama to avoid the embarrassment and litigation which elsewhere have been consequent on faulty surveys and descriptions. No survey not properly based in and referred to this triangulation should be countenanced in oyster leases granted by the State.

The biological and hydrographic survey, which was conducted by the Bureau of Fisheries, began about the middle of November, 1910, when the steamer *Fish Hawk* arrived in Mobile Bay, and it was concluded in May, 1911, part of the interim being employed in a similar survey in Mississippi waters. The purpose of the survey was the

accurate determination of the location, extent, and condition of the natural oyster beds and the examination of the barren bottoms in relation to their adaptability to oyster culture.

No oyster survey of the region covered by this report had been made previously, although the important beds adjacent to Grant's Pass had been the subject of reconnoissance in 1894.[a]

METHODS OF THE SURVEY.

The methods employed were those pursued in former surveys of like character and are explained in detail in a description of the beds of the James River,[b] from which some of the following is repeated:

A "boat sheet" was prepared, on which were accurately platted the positions, as determined by triangulation, of lighthouses, buildings, tripods, etc., used as shore signals. These data were furnished by the United States Coast and Geodetic Survey.

The oyster beds were discovered by soundings with a lead line, but principally by means of a length of chain dragged over the bottom at the end of a copper wire running from the sounding boat. The wire was wound on a reel and its unwound length was adjusted to the depth of water and the speed of the launch, so that the chain was always on the bottom. Whenever the chain touched a shell or an oyster the shock or vibration was transmitted up the wire to the hand of a man whose sole duty it was to give heed to such signals and report them to the recorder.

The launches from which the soundings were made were run at a speed of between 3 and 4 miles per hour. At intervals of three minutes—in some cases two minutes—the position of the boat was determined by two simultaneous sextant observations of the angles between a set of three signals, the middle one of which was common to the two angles, the position being immediately platted on the boat sheet. At regular intervals of 15 seconds, as measured by a clock under the observation of the recorder, the leadsman made a sounding and reported to the recorder the depth of water and the character of the bottom, immediately after which the man at the wire reported the character of the chain indications since the last sounding—that is, whether they showed barren bottom or dense, scattering, or very scattering growths of oysters.

With the boat running at 3 miles per hour the soundings were between 80 and 90 feet apart, and, as the speed of the boat was uniform, the location of each was determinable within a yard or two by dividing the platted distance between the positions determined by the sextant by the number of soundings. The chain, of course, gave

[a] Report of a reconnoissance of the oyster beds of Mobile Bay and Mississippi Sound, Ala., by Homer P. Ritter, assistant, United States Coast and Geodetic Survey. Published in Bulletin United States Fish Commission, vol. XV, 1895, p. 325–329, pl. 56–63.

[b] Moore, H. F.: Condition and extent of the oyster beds of James River, Va. Bureau of Fisheries Document No. 729.

a continuous indication of the character of the bottom, but the record was made at the regular 15-second intervals observed in sounding.

The chain, while indicating the absence or the relative abundance of objects on the bottom, gives no information as to whether they are shells or oysters, nor, if the latter, their size and condition. To obtain these data it was necessary to supplement the observations already described by others more definite in respect to the desired particulars. Whenever, in the opinion of the officer in charge of the sounding boat, such information was required, a numbered buoy was dropped, the time and number being entered in the sounding book. Another launch, following the sounding boat, anchored alongside the buoy, and a quantity of the oysters and shells were tonged up, separated by sizes, and counted.

This boat at each station made a known number of "grabs" with the oyster tongs, exercising care to clean the bottom of oysters as thoroughly as possible at each grab. In a given depth of water and using the same boat and tongs, an oysterman will cover practically the same area of the bottom at each grab, but, other factors remaining the same, the area of the grab will decrease with an increase in the depth.

Careful measurements were made and tabulated showing the area per grab covered by the tonger employed on the work at each foot of depth of water and for each pair of tongs and boat used. With these data, and knowing the number of "grabs," the number of oysters of each size per square yard of bottom was readily obtainable by simple calculation. The following example will illustrate the data obtained and the form of the record:

DEPARTMENT OF COMMERCE AND LABOR,
BUREAU OF FISHERIES.

Field record of examinations of oyster beds.

General locality, *Mississippi Sound, Ala.*
Local name of oyster ground, *Pass des Huitres.*
Date, *December 29, 1910.* Time, *1.05 p. m.*
Angle, *C 193–C 194.* Buoy No. *2.*
Depth, *3 feet.* Bottom, *Hard.*
Condition of water, *Clear.*
Density, *1.015.* Temperature, *58° F.*
Current, ... Stage of tide, *Flood.*
Tongman, *Bryant.*
No. grabs made, *6.* Tongs, *10 feet.*
Total area covered, *2.4* sq. yds.
No. oysters taken { —1 in., *6.* 1 in.–3 in., *119.* 3 in.–4 in., *33.* 4 in., *0.*
Quantity shells, *0.*
Result { Spat per square yard, *2.5.* Culls per square yard, *45.4.* Counts per square yard, *13.7.*

This furnishes an exact statement of the condition of the bed at the spot, which can be platted on the chart with error in position of not more than a few yards. From the data obtained a close estimate may be formed of the number of bushels of oysters and shells per acre in the vicinity of the examination, and, by multiplying the observations, for the bed as a whole. In the course of the survey 775 observations were made at various places, principally on the natural rocks, but some on the barren bottoms also.

In estimating the productiveness of the bottoms it appeared desirable to use the method employed in Delaware Bay [a] rather than that followed in the James River survey.

Where tongs are used exclusively a bed with a given quantity of oysters lying in shoal water is more valuable commercially than one with the same quantity of oysters in deep water, owing to the fact that the labor of the tonger is more efficient on the former. As has been pointed out, the area covered by a "grab" decreases with the depth, other factors being the same; and, moreover, the deeper the water the greater is the labor involved in making the grab and the smaller is the number of grabs which can be made in a given time. Where, however, the depth is practically uniform and shoal, as in the region treated in this report, it is unnecessarily refined and laborious to make such allowance for depth, and it is nearly as accurate and satisfactory to rate the bottoms in accordance with an arbitrary standard.

The classification adopted in this report is as follows:

Depleted bottom	Less than 25 bushels per acre.
Very scattering growth	Between 25 and 75 bushels per acre.
Scattering growth	Between 75 and 150 bushels per acre.
Dense growth	Over 150 bushels per acre.

In this classification no oysters less than 3 inches in length are considered, as the rating is made solely in respect to what are assumed to be marketable. It may therefore occur that bottom covered by an enormous growth of small oysters may be regarded, both in the text and on the chart, as depleted on account of the few large oysters which it bears. A reference to the tables which accompany the description of each bed will show cases of this kind. "Depleted bottom" is in a measure an unfortunate term, as it implies that it has retrograded in productiveness, whereas in reality in many cases it may be barren bottom gradually changing to productive. The term is employed to designate a definite present condition without regard to the past, and is retained despite its false implication, because no better has been suggested.

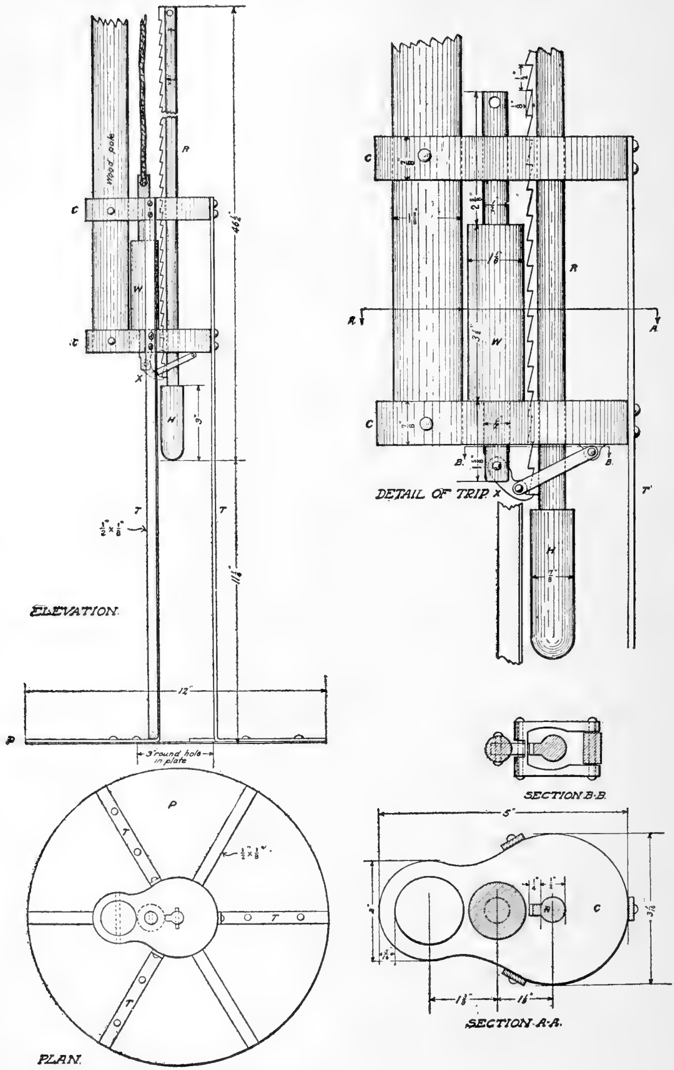
[a] Condition and Extent of the Natural Oyster Beds of Delaware. By H. F. Moore, assistant, United States Bureau of Fisheries. Bureau of Fisheries Document No. 745, 1911.

Under the biological and economic conditions obtaining in Mississippi Sound in 1910–11, the bottom rated as bearing a scattering growth, on which there are more than 75 bushels of marketable oysters per acre, is regarded as the least productive bottom capable of furnishing a livelihood to the tongers. Some of the very scattering growth may be capable of supporting a fishery for market, but most of it is not. On the other hand, some of the dense growth is of a character to make it practically worthless for market purposes, and while the oysters are abundant enough, the economic conditions are not such as to warrant tonging.

The barren bottom, which constitutes by far the greater part of the area covered by the survey, was examined principally with respect to the character, stability, and fixity of its constituent materials. This part of the investigation was more thorough and accurate than in any previously conducted, principally through the use of a mud-sounding machine devised by the writer several years ago. In previous surveys the character of the bottom has been determined by the indications of the sounding lead and pole, which are largely matters of opinion and will not correspond with any accuracy in the hands of different persons. To overcome this difficulty the Bureau now employs the instrument figured on next page. It consists of a large annular bottom (P), from which rises a tripod (T, T) supporting two castings (C and C). Passing freely through shaped orifices in the castings is a steel rod (R) 46½ inches long, provided with a rack and a plunger head (H) 3 inches long and ⅞ inch in diameter. Linked to the underside of the lower casting is a pawl (X) connected to the sliding weight (W), which, when at rest, engages with the rack in such manner as to prevent the fall of the rod.

To use the instrument, a pole of sufficient length is inserted in the eyes at the side of the castings. The rod is raised as far as it will go and is automatically locked in position by the rack and pawl. The instrument is then lowered until it rests on the bottom and the rod is released by pulling on a line attached to an eye at the upper end of the weight. As the plunger always falls through the same distance, it strikes the bottom with a uniform impact, and the depth of its penetration is a comparative measure of the consistency of the bottom.

In practice, the instrument is used from an anchored boat, and to secure a representative reading from 6 to 10 tests are made close together. Any markedly aberrant readings are eliminated, on the assumption that the plunger has either come into contact with an accidental obstruction, such as a shell, or has fallen into a crabhole or other minor cavity. The average of the remaining depths of penetration, read off in inches in a scale stamped on the rod, is



Mud sounding machine used to determine character of oyster bottom.

regarded as the index of the bottom consistency. The following arbitrary scale is adopted in this report.

Hard bottom	Penetration less than 4 inches.
Stiff	Penetration between 4 and 8 inches.
Soft	Penetration between 8 and 13 inches.
Very soft	Penetration between 13 and 18 inches.
Ooze	Penetration over 18 inches.

On the accompanying chart the consistency of the bottom is indicated by symbols which are more readily read than lettering—a black circle indicating hard bottom; a black semicircle, stiff mud; a black quadrant, soft mud; a circle containing two crossing diameters, very soft mud; and a circle with one diameter, ooze. Bottom falling within the first two classes, provided it be not shifting sand, is firm enough for oyster planting; the harder the bottom the more thickly the oysters may be planted without danger of becoming engulfed. Soft bottom should be used with care, and toward its upper limits may require preliminary hardening with sand or shells. Very soft bottom and ooze should not be considered. The instrument described has been given a thorough test and has shown itself to be satisfactory for the purpose of oyster surveys. Its readings are reliable where the consistency of the bottom is fairly uniform in the stratum penetrated, but there is likely to be an error of interpretation in the case of a hard sand or shell bottom overlaid by several inches of soft mud. Such cases are readily detectable, however, by probing with a pole, as is always done where the instrument is used.

In the prosecution of the work previously described, 357.1 miles of soundings were run and the chain was dragged over the bottom for the same distance, 16,960 soundings were made, and 3,340 angles for position of the boat were taken. Oysters were tonged, counted, and measured, and other biological observations made at 464 stations, and the consistency of the bottom was tested at 311 places exclusive of those on the oyster beds, a total of 775 places at which the bottom was examined. The survey covered a total area of 93,000 acres, of which 4,000 acres were oyster beds in which the sounding lines were closer together and the examinations made in more detail than on the barren bottoms.

The account of the oyster beds which follows proceeds from a detailed description of the several beds, with the data of all productive observations, to a consideration of the region as a whole and the requirements for its economic development.

DESCRIPTION OF THE NATURAL BEDS.

KINGS BAYOU REEF.

The name Kings Bayou Reef was somewhat doubtfully applied by the pilot to an oyster bed lying about 5 miles northeast of the end of Cedar Point. It is about $1\frac{1}{3}$ miles long and $\frac{1}{2}$ mile wide, its greater dimension being east and west, beginning 1 mile offshore in about 3 feet of water. This is an old reef, and, like the others in this part of Mobile Bay, it is built up in places several feet above the general level of the bottom. At its outer or offshore end the water shoals abruptly from 10 feet on the mud bottom to $6\frac{1}{2}$ feet on the reef.

The extent and character of the oyster growth on this bed are shown in the following table:

OYSTER GROWTH ON KINGS BAYOU REEF.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	39	296	234	11,544	9,126	20,670
Very scattering	40	205	91	8,200	3,640	11,840
Depleted	3	108	6	324	18	342
Total	82			20,068	12,784	32,852

The dense area is hook-shaped in outline and extends along the entire northern and western edges of the reef, with a brief gap near its middle, and it is probable that the reef consisted formerly of two dense areas separated by soft mud. The oysters are mostly in clusters of 8 or 9, often with very many small spat. The large oysters are long, oval, and thin edged. Very little débris was taken in the tongings.

The very scattering growths cover a compact area on the south side of the bed and extending between the two limbs of the dense area. On this part of the bed the depth varies from about $7\frac{1}{2}$ to 10 feet, indicating that it is of more recent development than the denser parts. There is yet no considerable accumulation of shells. While the quantity of large oysters per acre is but about 40 per cent of the number found on the area of dense growth, small oysters are nearly as abundant, ranging in places between 91 and 496 bushels per acre.

The depleted area is a small patch separating the two areas of dense growth above alluded to. While large oysters are scarce, there is a considerable quantity of young growth.

The details of examination of Kings Bayou Reef follows.

DETAILS OF EXAMINATION OF KINGS BAYOU REEF.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
1	Nov. 21, 1910	9.00	Dense	6.5	35.5	11.0	294	176	470
2	do	9.00	do	2.5	12.5	12.0	105	192	297
7	do	9.00	do	4.5	17.5	6.0	154	96	250
8	do	10.00	do	31.2	64.2	43.2	672	691	1,363
14	do	7.00	do	22.3	38.0	13.1	422	209	631
5	do	6.50	do	9.5	24.5	18.0	238	288	526
63	Nov. 22, 1910	5.50	do	10.0	11.1	9.0	148	144	292
64	do	3.50	do	14.7	32.2	9.1	328	146	474
65	do	6.00	do	11.1	32.7	10.0	307	160	467
3	Nov. 21, 1910	10.00	Very scattering	7.4	9.0	4.5	115	72	187
6	do	7.00	do	9.1	19.8	3.3	202	53	255
9	do	8.00	do	4.7	18.1	3.4	151	54	205
10	do	6.50	do	21.1	49.8	18.0	496	288	784
11	do	6.00	do	14.0	11.5	1.6	178	26	204
12	do	6.00	do	6.7	6.3	3.5	91	56	147
13	do	7.00	Depleted	8.4	1.4	.0	69	0	69
4	do	8.50	do	8.1	12.9	.8	147	13	160

BUOY REEF.

This reef, as defined in the present report, consists of a number of detached bodies of oysters varying from 1 to upward of 100 acres each. The name is apparently somewhat indefinitely applied, but is used here to designate the series of beds beginning with that lying south of the wreck buoy off Cedar Point and stretching northward for a distance of about $1\frac{3}{4}$ miles. This apparently includes all or part of what Ritter describes as Birmingham Reef. The large area lying south of the buoy is connected with Cedar Point Reef by an area of very scattering growth which doubtless marks an original line of separation between the two, over which oysters have been spread by the operation of dredges. In general all of these beds have sharply defined borders, rising abruptly a foot or two above the surrounding muddy bottom. They are resorted to principally by dredgers to whose use they are set apart by law. The oysters are in clusters.

The distribution of oysters according to density of growth is shown in the following table:

OYSTER GROWTH ON BUOY REEF.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	202	209	324	42,218	65,448	107,666
Scattering	34	165	108	5,610	3,672	9,282
Very scattering	19	76	62	1,444	1,178	2,622
Depleted	12	29	4	348	48	396
Total	267			49,620	70,346	119,966

The dense growth covers about 75 per cent of the total area, and either constitutes the entirety of the several beds or forms a center fringed by less dense areas, as shown in the chart.

The oysters are in clusters containing a fair proportion of large individuals. In the areas of dense growth, the market oysters exceed, numerically and in volume, the young under 3 inches in length, but on the less densely populated parts of the beds young oysters preponderate over the old ones. The depth of water over the areas of dense growth varies from 6 to 8½ feet and on the adjacent less dense parts of the beds it is usually a foot or two deeper.

A few drills were found here and some dead oysters, but in general the beds seem to be in good condition and capable of producing a good supply of oysters of indifferent quality. The market oysters on this and Kings Bayou and Cedar Point Reefs ran about 300 to the bushel, and it required over 700 of the small oysters under 3 inches in length to fill the same measure.

The following examinations were made:

DETAILS OF EXAMINATION OF BUOY REEF.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
32	Nov. 21, 1910	9.50	Dense	14.2	11.5	13.0	180	208	388
33	....do	9.00	....do	10.5	66.5	34.5	540	554	1,094
34	....do	8.00	....do	21 5	19.0	11.7	284	187	471
35	....do	8.00	....do	5.2	21.7	17.4	188	278	466
36	....do	7.00	....do	11.5	37.8	19.2	345	307	652
45	....do	10.50	....do	11.7	31.0	22.8	299	365	664
46	....do	10.00	....do	2.8	27.8	15.0	214	240	454
53	....do	10.00	....do	7.2	21.1	13.9	198	222	420
55	....do	10.00	....do	25.0	19.4	27.3	311	437	748
56	....do	8.00	....do	7.4	20.0	13.5	192	216	408
98	Nov. 22, 1910	8.50	....do	7.7	16.3	39.0	168	625	793
39	Nov. 21, 1910	8.00	....do	12.6	24.0	24.0	256	384	640
40	....do	7.00	....do	8.1	42.3	36.7	354	586	940
86	Nov. 22, 1910	9.50	....do	.0	15.2	22.6	106	362	468
87	....do	8.00	....do	.8	13.5	16.1	100	257	357
88	....do	8.00	....do	8.3	24.3	20.4	228	327	555
27	Nov. 21, 1910	7.50	....do	2.8	28.5	25.0	219	400	619
29	....do	8.00	....do	10.0	32.5	17.5	298	280	578
30	....do	8.00	....do	10.9	10.9	7.8	153	125	278
31	....do	9.00	....do	6.5	13.0	18.0	136	288	424
51	....do	7.00	....do	1.1	14.5	13.7	109	219	328
57	....do	10.00	....do	7.8	20.4	11.1	197	178	375
58	....do	8.00	....do	8.2	19.6	8.2	195	131	326
62	....do	9.00	....do	12.0	22.5	13.0	242	208	450
90	Nov. 22, 1910	8.00	....do	2.6	27.8	35.7	213	571	784
91	....do	9.50	....do	10.0	11.6	19.5	151	312	463
92	....do	8.00	....do	18.3	16.1	34.8	241	556	797
94	....do	9.00	....do	.0	24.5	6.5	172	104	276
95	....do	10.00	....do	4.5	8.9	12.8	94	205	299
100	....do	9.50	....do	1.0	3.2	17.9	29	286	315
101	....do	8.50	....do	10.0	17.7	30.4	194	487	681
102	....do	9.50	....do	14.7	18.4	15.2	232	243	475
106	....do	7.50	....do	15.6	22.8	22.8	269	365	634
24	Nov. 21, 1910	6.50	....do	15.0	61.0	27.0	533	432	965
25	....do	6.00	....do	5.1	29.0	31.0	238	495	733
26	....do	9.00	....do	5.0	47.5	22.0	367	352	719
105	Nov. 22, 1910	6.50	....do	5.5	14.2	33.4	138	535	673
21	Nov. 21, 1910	9.00	....do	.0	7.5	12.0	52	192	244
22	....do	8.00	....do	3.0	45.0	29.5	336	474	810
23	....do	9.00	....do	4.0	8.0	12.5	84	200	284
104	Nov. 22, 1910	8.00	....do	.0	9.6	32.6	67	522	589
103	....do	8.50	....do	5.9	11.8	12.7	124	203	327
20	Nov. 21, 1910	8.00	....do	.4	17.0	14.0	123	224	347
18	....do	9.00	....do	7.5	30.5	34.0	266	542	808

DETAILS OF EXAMINATION OF BUOY REEF—Continued.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
16	Nov. 21, 1910	8.00	Dense	3.4	29.7	9.4	232	150	382
17	do	8.00	do	2.5	9.0	9.9	81	158	239
66	Nov. 22, 1910	8.00	do	1.3	13.0	8.7	100	139	239
67	do	8.00	do	4.4	21.8	27.4	183	438	621
47	Nov. 21, 1910	10.00	Scattering	4.5	15.0	8.9	136	142	278
48	do	9.00	do	5.0	14.0	5.0	133	80	213
54	do	8.00	do	13.5	9.1	5.7	158	91	249
49	do	10.00	do	2.8	6.1	5.0	62	80	142
50	do	8.00	do	14.8	33.0	9.1	335	145	480
37	do	7.50	Very scattering	5.6	3.6	2.8	64	45	109
99	Nov. 22, 1910	7.00	do	8.9	10.0	6.3	132	101	233
93	do	9.00	do	6.0	13.0	3.5	133	56	189
15	Nov. 21, 1910	9.00	do	.0	.0	4.0	0	64	64
19	do	9.00	do	.0	2.5	2.0	17	32	49
78	Nov. 22, 1910	10.00	do	6.7	8.9	4.5	109	72	181
28	Nov. 21, 1910	10.00	Depleted	.0	1.2	.0	8	0	8
89	Nov. 22, 1910	10.00	do	.0	.0	.0	0	0	0
59	Nov. 21, 1910	11.00	do	.0	.0	.0	0	0	0
60	do	11.00	do	7.3	6.0	.0	93	0	93
61	do	10.00	do	7.8	7.2	1.1	105	18	123
107	Nov. 22, 1910	10.00	do	.0	.0	.0	0	0	0
44	Nov. 21, 1910	12.00	do	.0	.0	.7	0	11	11

CEDAR POINT REEF.

This is a long, narrow bed extending from the end of Cedar Point for a distance of about 1½ miles toward the wreck buoy. It is now connected with the southernmost bed of Buoy Reef by a very scattering growth lying on what was comparatively recently barren bottom, the original zone of separation being indicated by a narrow gully carrying 8½ feet of water lying between depths of about 6 feet on the adjacent parts of the two reefs. It is probable that this very scattering growth is the artificial product of dredging operations.

The area, density of growth, and estimated content of small and market oysters are shown in the following table:

OYSTER GROWTH ON CEDAR POINT REEF.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	100	140	340	14,000	34,000	48,000
Scattering	21	121	130	2,541	2,730	5,271
Very scattering	24	36	41	864	984	1,848
Depleted	56	89	0	4,984	0	4,984
Total	201			22,389	37,714	60,103

The reef consists of a narrow ridge of very dense growth extending from the gully above mentioned, flanked by scattering and very scattering growths along the southern edge of its offshore half and on the northern edge of its inshore half by a fringe which gradually

decreases shoreward from a scattering growth to a depleted area which extends to low-water mark. For the outermost mile of its length the reef is hardly more than 200 yards in width and the dense growth averages about 100 yards wide. Within a half mile of shore the dense area expands and curves southward to connect with the corresponding area of Pass des Huitres bed. The proportion of market oysters to small ones is generally high throughout this dense area and is relatively much lower on the less densely populated bottoms.

As has been already stated, the scattering and very scattering growths occur as fringes along the edges of the dense growth. The depleted area expands on the shoreward part of the reef, extending from the dense growth to the shore, as widely scattered clusters of small oysters lying on the sand. These clusters lie in very shoal water, and although the growth was not examined with care, it apparently extends for some distance northward from the end of Cedar Point.

The depth of water lying over Cedar Point Reef varies from 6½ feet at its outer end to less than 2 feet at the inner edge of the area of dense growth. The surrounding water is generally about 2 feet deeper than over adjacent parts of the reef.

The following table shows in detail the results of the examinations made on the bed:

Details of Examination of Cedar Point Reef.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					Bush.	Bush.	Bush.
38	Nov. 21, 1910	9.00	Dense	7.5	60.0	44.5	473	706	1,179
41	do	6.00	do	8.0	19.4	19.4	192	310	502
42	do	7.00	do	4.8	21.5	23.0	184	368	552
69	Nov. 22, 1910	6.00	do	1.6	9.0	6.8	74	109	183
70	do	5.00	do	5.9	9.0	9.7	104	155	259
73	do	6.00	do	6.7	17.8	23.3	172	373	545
74	do	8.00	do	14.0	14.6	19.4	200	310	510
75	do	7.00	do	16.0	4.0	9.3	140	149	289
80	do	5.50	do	10.5	12.6	15.2	162	243	405
81	do	8.00	do	6.0	7.3	18.0	93	288	381
83	do	8.00	do	4.0	27.3	24.6	219	394	613
84	do	7.00	do	1.9	13.0	17.4	104	278	382
85	do	6.00	do	1.0	18.4	35.2	136	564	700
96	do	9.25	do	.0	8.5	16.5	59	264	323
108	do	7.00	do	.7	8.9	30.4	67	487	554
109	do	6.00	do	.6	11.9	14.7	87	236	323
110	do	5.00	do	2.4	17.6	44.8	140	717	857
111	do	7.00	do	.7	.0	20.6	5	332	337
113	do	5.00	do	.0	7.1	11.4	50	182	232
97	do	7.00	Scattering	2.6	6.7	7.8	65	125	190
79	do	6.00	do	12.3	19.0	8.1	219	130	349
71	do	5.50	do	3.2	7.9	8.4	78	134	212
43	Nov. 21, 1910	9.00	Very scattering	.0	.0	.0	0	0	0
82	Nov. 22, 1910	8.50	do	2.0	6.0	2.7	56	43	99
76	do	8.00	do	3.3	2.0	3.3	37	53	90
112	do	6.00	do	1.1	5.5	3.8	46	61	107
72	do	6.00	do	1.1	5.0	2.8	43	45	88
68	do	6.50	Depleted	12.2	.5	.0	89	0	89

PASS DES HUITRES BED.

This is a bed of indeterminate boundaries, being continuous with Cedar Point bed on the north and on the south with Pass des Huitres Flats and the whole series of beds extending to Dauphin Island Bay inside of Grants Pass and as far as Pass Drury in Mobile Bay. The names applied by the oystermen to the beds in the vicinity of Grants Pass designate general localities rather than defined beds, and for the purposes of this report their boundaries have been arbitrarily selected and are not definitely indicated on the chart. For this reason the areas assigned to the several beds may differ somewhat from those which would be regarded by others as proper, but as the excess or deficiency of one bed is compensated for by decreasing or increasing its neighbors, the total area of all of the beds, which is the important fact, is not affected. Pass des Huitres bed takes its name from a channel having about 13 feet in its deepest part and shoaling to 4 feet or less at each end, which sweeps in a curve about 350 yards off the end of Cedar Point. Its area and the conditions of its oyster growth are shown in the following table:

OYSTER GROWTH ON PASS DES HUITRES BED.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	53	365	303	19,345	16,059	35,404
Scattering	30	213	92	6,390	2,760	9,150
Total	83			25,735	18,819	44,554

The dense growth lies principally south and east of the channel, though some of the bottom most prolific of market oysters is in the deepest water. Most of the marketable oysters are between 3 and 4 inches long, but in the deeper water the proportion of larger ones is greater than elsewhere. There is a good ratio of single oysters and small clusters on this bed and the shape is therefore better than on the beds previously described. The quality at the time of examination was fair.

The scattering growth lies north of the channel on the edge of the barren bottom extending to Cedar Point. The oysters on this area of hard sand and shell bottom are nearly all single or in small clusters. There were, in December, 1910, practically no oysters over 4 inches in length and a great abundance of individuals less than 3 inches long.

The following table exhibits the data obtained from the examination made of this bed:

DETAILS OF EXAMINATION OF PASS DES HUITRES BED.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
445	Dec. 29, 1910	3.50	Dense	1.8	31.8	6.4	235	104	339
446	....do	4.00	....do	.0	30.0	18.0	210	288	498
447	....do	5.00	....do	15.7	77.5	20.6	654	330	984
449	....do	5.00	....do	.0	71.3	23.2	499	372	871
496	Jan. 1, 1911	2.00	....do	2.0	33.5	17.5	249	280	529
497	....do	2.50	....do	.0	48.8	18.9	342	302	644
530	Jan. 5, 1911	11.00	....do	4.1	65.7	25.0	486	400	886
531	....do	13.00	....do	4.5	30.9	21.8	248	350	598
448	Dec. 29, 1910	4.00	Scattering	5.5	13.0	6.5	129	104	233
450	....do	5.00	....do	2.5	33.2	5.0	250	80	330
451	....do	4.00	....do	3.5	40.1	7.5	305	120	425
532	Jan. 5, 1911	7.00	....do	4.8	19.2	4.0	168	64	232

PASS DES HUITRES FLATS.

This bed, contiguous with the preceding and the following, lies on the shallow flats south of Pass des Huitres, where the depth at low water ranges from 6 inches to 2 feet, excepting on the western side, where a depth of 5 feet is found on the edge of the area of very scattering growth.

The area, density of growth, and total content of oysters on the bed as arbitrarily defined in this report are shown in the following table:

OYSTER GROWTH ON PASS DES HUITRES FLATS.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	122	296	304	36,112	37,088	73,200
Scattering	41	131	139	5,371	5,699	11,070
Very scattering	39	26	46	1,014	1,794	2,808
Total	202			42,497	44,581	87,078

The dense growth lies in the part of the bed toward Mobile Bay, where it commences as a sharply defined ridge rising abruptly from a depth of about 3 feet over the mud to about 1 foot near the edge of the oysters. The eastern part of the dense area is composed of a mass of shells, but in the western part there are some sandy areas covering a shelly substratum.

The scattering growth merges with the western edge of the dense area where the water begins to deepen, and this in turn passes gradually to an area of very scattering oysters lying on soft mud in which

are many buried shells. The majority of the oysters on this part of the bed are large, over 4 inches in length, while elsewhere, particularly on the dense growth, there are comparatively few such oysters, and most of the smaller ones, both market oysters and culls, are in large closely compacted clusters.

The data gathered by the several examinations on this bed are as follows:

DETAILS OF EXAMINATION OF PASS DES HUITRES FLATS.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					Bush.	Bush.	Bush.
442	Dec. 29, 1910	3.00	Dense	6.3	35.8	18.7	295	299	594
443	do	3.00	do	2.5	45.4	13.7	346	219	565
444	do	3.00	do	10.0	45.4	17.1	388	274	662
452	do	5.50	do	2.7	10.0	10.0	89	160	249
489	Jan. 1, 1911	1.80	do	3.5	55.5	42.0	414	672	1,086
490	do	2.20	do	.0	8.0	6.0	56	96	152
491	do	2.50	do	7.2	34.2	23.2	290	372	662
492	do	1.40	do	3.6	30.5	11.4	239	182	421
493	do	2.10	do	.0	67.5	38.0	473	604	1,077
494	do	2.00	do	.0	29.0	11.5	203	183	386
495	do	2.40	do	5.0	61.7	17.8	467	284	751
488	do	2.80	Scattering	.6	18.1	8.7	131	139	270
453	Dec. 29, 1911	6.00	Very scattering	.0	3.6	2.9	26	46	72

DUTCH GULLY.

Dutch Gully bed lies in and about an area of slightly deeper water between Pass des Huitres Flats on the north and Big Gully and Dutch Island beds on the south. The depth of the water ranges from about 6 inches to 3 or 4 feet, the latter depth lying on the area of scattering growth. Although this bed, like the others in the vicinity, is without well defined boundaries, it is assumed in this report to have approximately the following area, density of growth, and oyster content:

OYSTER GROWTH ON DUTCH GULLY BED.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	Bushels.	Bushels.	Bushels.	Bushels.	Bushels.
Dense	39	206	253	8,034	9,867	17,901
Scattering	19	222	101	4,218	1,919	6,137
Total	58			12,252	11,786	24,038

The dense growth, which lies principally in a depth of less than 2½ feet, occupies the central part of the bed. The clusters generally are small with a considerable proportion of single oysters. The

market oysters are of medium size, most of them being between 3 and 4 inches long with a few of greater length. The young growth is prolific. The areas of scattering growth are two, lying respectively to the east and west of the dense growth in slightly deeper water. In these areas the oysters are generally in clusters, lying on a hard bottom. The young growth is slightly more abundant than on the denser portions of the bed.

The following table expresses the details of the several examinations made on the bed:

DETAILS OF EXAMINATION OF DUTCH GULLY.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
475	Dec. 31, 1910	1.8	Dense	2.3	31.3	15.3	235	245	480
476	....do	1.0	....do	1.3	23.3	16.8	172	269	441
477	....do	2.8	....do	.8	22.2	15.4	211	246	457
485	....do	4.3	Scattering	2.3	33.1	8.5	248	136	384
487	....do	1.0	....do	9.6	18.3	4.2	196	67	263

WEST SIDE OF DUTCH ISLAND.

Dutch Island is a small shell bank called Gull Island on the Coast Survey charts. The oyster bed designated by the name used above extends from the western edge of the island to barren bottom, between Dutch Gully and Peter Billy's Gully.

The following table exhibits in summary the data relating to this bed:

OYSTER GROWTH ON WEST SIDE OF DUTCH ISLAND.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	42	322	279	13,524	11,718	25,242
Scattering	21	298	99	6,258	2,079	8,337
Depleted	24	165	13	3,960	312	4,272
Total	87	....	....	23,742	14,109	37,851

Close to Dutch Island there is an area of hard shelly bottom with a growth of densely clustered irregular-shaped small oysters, practically devoid of market stock. Over most of this area the water is very shallow, reaching a maximum of 2 feet. To the westward of this is an area of dense growth, most of which lies in water from 2 to 4 feet deep, with a maximum of about 5 feet at its western edge. On this part of the bed there are few oysters over 4 inches long, most of

the so-called market stock being between 3 and 4 inches in length and growing in heavy clusters. The scattering growth lies in a zone between the dense growth and the soft muddy bottom of Mississippi Sound in an average depth of water of about 5 feet. Practically none of the oysters of marketable size are over 4 inches long. On both this area and on the bottom covered with dense growth young oysters are abundant, varying from 180 to 546 bushels per acre, with an average density of over 300 bushels per acre.

The following data state the results of the examinations made on this bed:

DETAILS OF EXAMINATION OF DUTCH ISLAND.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
436	Dec. 29, 1910	4.50	Dense	4.4	53.8	17.4	408	228	636
437	do	4.00	do	.5	25.5	12.5	182	200	382
438	do	5.00	do	5.6	72.5	29.4	546	470	1,016
473	Dec. 31, 1910	1.00	do	3.6	28.4	16.9	224	270	494
474	do	3.00	do	2.5	33.4	14.2	252	227	479
433	Dec. 29, 1910	5.00	Scattering	6.2	44.5	5.6	355	88	443
439	do	5.00	do	9.4	25.0	6.8	241	109	350
472	Dec. 31, 1910	3.00	Depleted	4.2	19.4	.8	165	13	178

BIG GULLY.

This bed, which it is understood is also known as Grants Pass Gully, lies between the dolphin, or cluster of piles marking the eastern entrance to Grants Pass, and Dutch and Grant Islands. The depth of water varies from 9 or 10 feet close to the dolphin to less than 1 foot near the island.

The area of density of growth and total content of small and marketable oysters are shown in the following table:

OYSTER GROWTH ON BIG GULLY BED.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	44	284	310	12,496	13,640	26,136
Scattering	10	277	80	2,770	800	3,570
Depleted	11	0	0	0	0	0
Total	65			15,266	14,440	29,706

In the deeper water close to the dolphin and for a distance of 200 or 300 yards west and northwest in the area indicated as "depleted" on the chart, there are practically no oysters, either large or small, the bottom being composed in large part of soft mud with buried

shells. The area of scattering growth lies south and west of this in a depth of water between 1 and 5 feet. Although this part of the bed bears but about one-fourth as many market oysters per acre as are found on the dense area, there are practically as many small ones. The bottom bearing the dense growth of market oysters lies between that just described and Dutch and Grant Islands, its western limit being defined by the very shallow water extending from Dutch toward Grant Pass. The depth of the water ranges from about 1 to 5 feet and the market oysters vary in quantity from 160 to upward of 600 bushels per acre. The densest growth occurs north of Grant Island, and on the steps lying between that point and Gull Island there is a large proportion of single oysters, a considerable number of them being large.

The foregoing description is based in part on the data shown in the following table:

DETAILS OF EXAMINATION OF BIG GULLY (GRANTS PASS GULLY).

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
478	Dec. 31, 1910	5.0	Dense	0.6	30.0	19.4	214	311	525
480	.....do	5.0	.....do	3.1	27.4	10.0	213	160	373
482	.....do	2.0	.....do	1.0	50.0	38.0	357	604	961
484	.....do	1.6	.....do	4.1	46.0	10.4	351	166	517
483	.....do	1.2	Scattering	1.2	38.4	5.0	277	80	357
479	.....do	7.0	Depleted	.0	.0	.0	0	0	0

PETER BILLYS GULLY.

This lies opposite Big Gully and on the west side of the shallow water lying south of Dutch Island. It includes the oysters lying between the bed on the west side of Dutch Island and Grants Pass bed and is continuous with both. Its area, character of oyster growth, and contents are shown in the following table:

OYSTER GROWTH IN PETER BILLYS GULLY.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	39	324	245	12,636	9,555	22,191
Very scattering	14	40	38	560	532	1,092
Depleted	28	0	6	0	168	168
Total	81	....	....	13,196	10,255	23,451

The eastern part of this bed is a small area of very scattering growth lying north of a long shell bank west of Grants Island. It lies in the very shoal water which stretches north to Gull Island, on a deposit of an inch or two of soft mud on a substratum of hard sand and shells. The oysters are small and poor. West of this lies the dense growth covering an area of about 39 acres in a depth of water varying from 1 to 5 feet. This bottom consists of densely compacted sand and shells, with oysters of the raccoon type in clusters. On the western border of this growth there is a depleted area on which there are few oysters of any size. The bottom changes gradually from hard sand and shell close to the dense area to soft mud with buried shells on the western border of the bed.

DETAILS OF EXAMINATION OF PETER BILLYS GULLY.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
428	Dec. 29, 1910	5.00	Dense	5.6	38.7	15.6	310	250	560
431	do	4.50	do	4.4	76.1	15.5	564	248	812
432	do	4.00	do	4.0	58.0	26.5	434	424	858
468	Dec. 31, 1910	3.00	do	1.2	30.4	11.2	221	179	400
470	do	1.00	do	.0	21.9	9.7	153	155	308
471	do	3.00	do	1.7	35.8	13.3	263	213	476
469	do	1.50	Very scattering	.0	5.7	2.4	40	38	78
430	Dec. 29, 1910	5.50	Depleted	.0	.0	.7	0	11	11
434	do	6.00	do	.0	.0	.0	0	0	0

GRANTS PASS.

Grants Pass is a dredged channel cut through the oyster beds which extend as a practically unbroken reef from Cedar Point to Little Dauphin Island and separate Mobile Bay from Mississippi Sound. The channel itself carries a minimum depth of about 11 feet, but at the Mobile Bay end the water shoals to about 8½ feet, and opposite the western or Mississippi Sound end to about 6½ feet at low water. There is a row of 7 dolphins or clusters of piles for 25 to 60 yards north of the thread of the channel. The oyster bed designated by the name of this pass is here arbitrarily assumed to lie not only in the deep water of the channel, but to extend as a strip about 200 to 250 yards wide on each side of the row of piles above described, with the exception of the cluster at the Mobile Bay end, which is assumed to lie in Big Gully bed. This bed was extensively worked by tongers during the period of the survey and with Pass aux Herons, which adjoins it to the south, produced the bulk of the oysters taken by tonging in the winter of 1910–11.

The extent and productiveness of this bed are shown on the table following.

OYSTER GROWTH IN GRANTS PASS.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	64	275	359	17,600	22,976	40,576
Scattering	21	159	112	3,339	2,352	5,691
Depleted	42	70	22	2,940	924	3,864
Total	127			23,879	26,252	50,131

About one-half of the area included within this bed is covered by a dense growth of market oysters, the eastern half being especially productive. The oysters are larger than most of those produced in this region and of better shape. There are many in the channel, especially south and east of Grants Island, but on account of the deep water, which reaches a maximum of 19 feet, and the strong currents the work is arduous at most times, and most of the tonging is done in depths of from 3 to 5 or 6 feet on the south side of the eastern half of the channel. No boats were observed at work on the north side of the row of dolphins.

The scattering growth on this bed lies in two patches—one of about 13 acres surrounding Grants Island and the other of about half the size between the easternmost two channel marks and continuous with the similar growth on Big Gully bed. The oysters in the latter area are somewhat larger and better than those surrounding Grants Island. The depleted bottom lies at the western end of the bed, between the dense growth and the barren bottom. Both the young and the market oysters here lie in patches of varying productiveness.

The following table shows the character of this bed at the several places at which detailed examinations were made:

DETAILS OF EXAMINATION OF GRANTS PASS.

Station No.	Date of examination.	Depth of water.	Character of growth	Oysters caught per square yard.			Estimated quantity of oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
180	Nov. 24, 1910	7.00	Dense	6.7	31.1	25.6	265	410	675
299	Dec. 8, 1910	4.30	do	14.5	14.5	17.0	203	272	475
425	Dec. 29, 1910	5.00	do	7.5	23.8	17.5	219	280	499
426	do	4.50	do	10.6	31.8	20.6	297	330	627
427	do	4.00	do	.0	46.5	16.5	326	264	590
525	Jan. 5, 1911	17.00	do	10.8	30.0	23.3	281	373	654
526	do	13.00	do	5.0	25.0	45.0	210	720	930
528	do	14.00	do	10.0	51.0	20.0	427	320	747
529	do	11.00	do	2.5	32.5	16.6	245	265	510
178	Nov. 24, 1910	6.25	Scattering	5.2	13.2	7.7	129	123	252
179	do	6.50	do	17.1	5.5	7.1	158	114	272
481	Dec. 31, 1910	2.00	do	17.4	21.2	5.5	271	88	359
527	Jan. 5, 1911	13.00	do	5.4	5.9	7.7	79	123	202
300	Dec. 8, 1910	4.50	Depleted	13.3	6.1	.0	136	0	136
301	do	5.30	do	.0	.0	1.3	0	21	21
422	Dec. 29, 1910	5.50	do	3.3	.0	.0	23	0	23
423	do	5.50	do	2.0	3.3	5.3	37	85	122
424	do	3.00	do	17.5	4.2	.4	152	6	158

PASS AUX HERONS.

This bed is continuous with the preceding and the following, without any definite demarcation of its boundaries. It surrounds a hole or blind pass from which it takes its name, in which there is a maximum depth of water of about 18 feet. The depth rapidly decreases, the water becoming quite shoal on each side and at the western end, although a draft of 5 or 6 feet can be carried on to the eastern end at low water.

This is in every respect the most important and prolific of the beds examined, and with the exception of Sand Reef, which has little or no present economic importance, it is, as arbitrarily defined here, the largest.

The following table summarizes the data relating to its extent, character of oyster growth, and content of oysters:

OYSTER GROWTH IN PASS AUX HERONS.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	211	233	520	49,163	109,720	158,883
Scattering	14	32	94	448	1,316	1,764
Very scattering	43	78	53	3,354	2,279	5,633
Depleted	24	15	4	360	96	456
Total	292			53,325	113,411	166,736

A dense growth having an average content of 520 bushels of market oysters per acre covers nearly 75 per cent of the entire area assumed for this bed, and in one place there are 1,170 bushels of market oysters and 1,494 bushels of all sizes per acre. The densest part of the bed lies between the deep water of the pass and Grants Pass, principally south and southeast of Grants Island. There is also a very dense area in a peninsula-like projection into Mobile Bay, about east of Grants Island and surrounded on the northeast and west by soft mud. During the winter of 1910–11 there were many tongers operating on these areas of very dense growth, and the best oysters produced in large quantities came from them. A larger proportion of oysters over 4 inches long was found here than at any other place examined in this vicinity. The areas of scattering growth occur in small patches of 9 and 4 acres, respectively, at the eastern or western limits of the bed. In the larger area the oysters are similar to those on the dense growth, with a considerable proportion of large ones of fair shape and quality.

There are three areas of very scattering growth, one at the eastern edge of the peninsula above referred to, another along the western

edge of the dense area and the third separated from the preceding by a narrow belt of depleted bottom and continuous with the scattering growth at the western limit of the bed, the two constituting practically a small detached bed.

DETAILS OF EXAMINATION OF PASS AUX HERONS.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
165	Nov. 23, 1910	9.00	Dense	0.0	1.0	6.0	7	96	103
166	do	8.00	do	4.4	7.0	20.0	80	320	400
167	do	7.00	do	11.1	10.0	20.7	148	333	481
168	do	7.00	do	8.9	20.3	32.2	203	516	719
169	do	6.00	do	8.1	22.5	30.0	214	480	694
170	do	10.00	do	7.2	38.3	46.7	319	746	1 065
171	do	7.50	do	5.2	33.2	36.4	269	583	852
176	do	5.25	do	14.0	22.9	10.5	258	168	426
177	do	4.50	do	41.8	61.3	15.3	722	245	967
181	Nov. 24, 1910	7.00	do	11.8	24.1	39.6	251	634	885
182	do	6.00	do	4.2	32.3	38.4	256	615	871
183	do	6.50	do	16.6	21.7	28.3	268	453	721
184	do	6.00	do	11.9	40.0	52.3	364	837	1,201
185	do	5.50	do	2.1	26.3	36.3	199	580	779
186	do	4.00	do	11.9	34.4	73.3	324	1,170	1,494
187	do	4.00	do	11.1	41.8	38.6	370	618	988
188	do	5.00	do	15.2	36.2	19.0	360	304	664
189	do	6.00	do	3.9	49.5	58.9	374	942	1,316
190	do	7.50	do	8.0	50.8	56.7	412	908	1,320
280	Dec. 8, 1910	4.00	do	2.9	28.6	38.8	220	620	840
281	do	3.60	do	.7	23.1	60.0	167	960	1,127
282	do	3.50	do	6.2	20.3	25.9	186	414	600
283	do	3.60	do	2.8	34.8	23.8	263	381	644
284	do	4.00	do	8.9	18.1	58.9	189	954	1,143
285	do	4.80	do	2.4	39.5	36.7	294	588	882
286	do	4.40	do	.0	18.8	20.8	132	333	465
287	do	3.70	do	3.0	18.2	38.5	148	616	764
288	do	4.00	do	1.5	18.5	50.8	140	812	952
289	do	3.30	do	1.9	19.4	13.5	149	216	365
290	do	3.50	da	.7	26.9	31.7	193	506	699
291	do	3.70	do	1.4	44.2	14.3	320	229	549
292	do	4.50	do	2.5	42.5	64.6	315	1,030	1,345
293	do	4.20	do	.7	27.5	40.0	197	640	837
294	do	2.60	do	5.9	31.1	37.8	259	604	863
295	do	2.80	do	8.3	28.8	54.6	260	874	1,134
296	do	3.30	o	.0	6.7	4.2	47	67	114
297	do	3.90	do	.7	12.5	20.5	92	328	420
298	do	3.80	do	5.0	18.0	21.0	161	336	497
305	do	4.00	do	.5	24.5	36.5	175	584	759
309	do	3.20	do	7.1	17.5	12.9	172	206	378
331	Dec. 9, 1910	2.30	do	6.4	15.1	28.4	151	454	605
332	do	2.80	do	21.7	56.2	29.6	545	473	1,018
[a] 342	do		do						
520	Jan. 2, 1911	18.00	do	.0	14.7	22.7	103	363	466
522	Jan. 5, 1911	18.00	do	9.2	16.6	3.0	180	48	228
524	do	17.00	do	5.8	41.6	34.0	332	544	876
173	Nov. 23, 1910	10.00	do	4.5	15.6	31.2	141	500	641
174	do	10.00	do	.0	3.3	12.2	23	195	218
172	do	10.00	Scattering	1.7	0.6	4.5	16	72	88
175	do	7.00	do	.0	1.5	3.0	10	48	58
191	Nov. 24, 1910	9.50	do	2.1	3.1	8.9	36	142	178
310	Dec. 8, 1910	5.80	do	.7	8.5	7.1	64	114	178
192	Nov. 24, 1910	7.50	Very scattering	1.6	.0	2.4	11	38	49
304	Dec. 8, 1910	3.80	do	6.5	4.0	6.5	70	104	174
306	do	4.30	do	2.0	1.5	2.5	25	40	65
307	do	3.80	do	1.5	3.0	2.5	32	40	72
308	do	3.40	do	10.9	6.4	2.7	121	43	164
313	do	3.40	do	26.4	10.0	3.6	255	58	313
242	Dec. 7, 1910	5.50	do	4.7	.0	3.2	33	51	84
302	Dec. 8, 1910	4.60	Depleted	2.2	.0	.0	15	0	15
303	do	4.20	do	2.0	2.5	1.0	32	16	48
311	do	4.90	do	.0	.0	.0	0	0	0
312	do	3.50	do	4.5	1.8	.5	44	8	52
314	do	4.80	do	.0	.0	.0	0	0	0
315	do	5.20	do	.0	.0	.0	0	0	0

[a] Exposed reef; living oysters large and small.

REDFISH GULLY.

Redfish gully is a strip of slightly deeper water lying between the shoals south of Pass aux Herons and the bar, bare at extreme low tide in winter, extending for about 800 yards northwest from the tip of Little Dauphin Island. The shallowest part of this gully has a depth of about 3 feet at low water, the average is about 6 inches deeper and near the western end is a hole in which there is a maximum of 7 feet or more. The oyster bed designated by this name lies in and about the gully.

The following table shows the extent, character of oyster growth, and estimated content of this bed:

Oyster Growth in Redfish Gully.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	209	231	313	48,279	65,417	113,696
Scattering	11	26	80	286	880	1,166
Total	220			48,565	66,297	114,862

Practically all of this bed consists of dense growth, there being but one patch of about 11 acres of scattering oysters near the northeast edge, where there is a considerable proportion of large oysters of good shape.

On the dense growth market oysters are least abundant in and about the deeper water in the southwestern part of the bed. The proportion of oysters over 4 inches in length is greatest in the eastern part of the bed, adjoining Mobile Bay, and it was there that most of the boats were observed working on the bed, although there were three or four schooners operating in the deep hole.

Details of Examination of Redfish Gully.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
156	Nov. 23, 1910	7.00	Dense	5.3	20.0	30.7	177	492	669
157	do	5.00	do	13.8	31.4	38.1	317	610	927
158	do	4.50	do	8.1	10.7	27.0	132	432	564
159	do	6.00	do	12.8	26.6	24.4	276	391	667
160	do	6.00	do	11.1	18.3	13.3	206	213	419
161	do	8.00	do	7.3	7.3	14.7	102	235	337
193	Nov. 24, 1910	7.00	do	13.3	14.5	10.7	195	171	366
211	do	3.40	do	.0	21.0	21.9	147	350	497
321	Dec. 8, 1910	3.90	do	11.5	11.5	11.0	161	176	337
322	do	4.00	do	4.0	19.5	10.5	165	168	333
323	do	4.40	do	4.4	30.0	20.0	241	320	561
324	do	4.40	do	2.2	28.8	10.0	217	160	377
333	Dec. 9, 1910	2.00	do	5.8	42.0	23.6	335	378	713
339	do	6.20	do	12.3	26.2	26.9	270	430	700
340	do	2.90	do	13.1	51.3	28.8	451	461	912
341	do	2.90	do	9.6	22.9	5.4	228	864	1,092
343	do	2.90	do	2.1	41.7	26.3	307	470	777
162	Nov. 23, 1910	8.00	Scattering	2.0	5.3	3.3	51	53	104
163	do	6.00	do	.0	.0	6.7	0	107	107

BLACK LUMPS.

This bed lies west of Redfish Gully and south of the western part of Pass aux Herons and is continuous with both. The name as used by the oystermen appears to be of very indefinite application and is probably more restricted than as employed in this report. Some of the oysters in the part immediately adjoining Pass aux Herons are excellent, but in most places they are inferior. Drills were found in abundance at places on this bed and a great many small spat had been killed by them.

The area, conditions of oyster growth, and total contents of seed and marketable oysters are shown in the following table:

OYSTER GROWTH ON BLACK LUMPS.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Scattering	13	140	139	1,820	1,807	3,627
Very scattering	49	136	49	6,664	2,401	9,065
Depleted	77	14	3	1,078	231	1,309
Total	139			9,562	4,439	14,001

The scattering growth occurs as a small area adjoining the southwest corner of Redfish Gully bed, and south of it is a small patch of very scattering growth. A larger area of the latter is found at the northeast corner of the bed, in the angle between Pass aux Herons and Redfish Gully beds. The depleted bottom, which comprises the major part of the bed, lies in the western and southern part.

The detailed data of the examination are as follows:

DETAILS OF EXAMINATION OF BLACK LUMPS.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity of oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
325	Dec. 8, 1910	4.40	Scattering	4.4	15.6	8.7	140	139	279
386	Dec. 16, 1910	3.40	Very scattering	3.2	5.5	1.8	61	29	90
334	Dec. 9, 1910	3.90	do	27.5	24.0	8.0	351	128	479
337	do	3.70	do	8.2	1.8	1.8	70	29	99
338	do	2.20	do	20.0	13.6	1.9	235	30	265
519	Jan. 2, 1911	12.00	do	1.4	7.2	2.8	60	45	105
521	Jan. 5, 1911	14.00	do	1.5	4.2	2.1	40	34	74
317	Dec. 8, 1910	4.90	Depleted	2.5	.0	.0	18	0	18
318	do	3.50	do	.0	.0	.0	0	0	0
319	do	3.00	do	.0	.0	.0	0	0	0
320	do	3.00	do	7.1	.0	1.3	50	21	71
335	Dec. 9, 1910	5.70	do	.7	.0	.0	5	0	5
336	do	5.70	do	.0	.0	.0	0	0	0
316	Dec. 8, 1910	2.80	do	3.3	2.1	.0	38	0	38
239	Dec. 7, 1910	4.50	do	.0	.0	.0	0	0	0

WEST SIDE OF LITTLE DAUPHIN ISLAND.

This is an economically unimportant bed lying between the Turtle Hole, Mussel Gully, and Redfish Gully. A large part of it lies on bottom which is exposed during low winter tides. The extent and density of oyster growth are as follows:

OYSTER GROWTH ON WEST SIDE OF LITTLE DAUPHIN ISLAND.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Very scattering	9	58	35	522	315	837
Depleted	156	9	4	1,404	624	2,028
Total	165	....	....	1,926	939	2,865

There is an insignificant patch of very scattering growth adjoining a small shell island northeast of Turtle Hole, and the rest of the bed is depleted. The proportion of dead oysters is very large in all parts of the bed, and drills, which appear to be the principal cause of the mortality, are abundant. The following examinations were made:

DETAILS OF EXAMINATION OF WEST SIDE OF LITTLE DAUPHIN ISLAND.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
392	Dec. 16, 1910	1.00	Very scattering	0.8	7.5	2.2	58	35	93
326	Dec. 8, 1910	3.80	Depleted	.0	.0	.0	0	0	0
327	....do	2.60	....do	4.1	.0	.7	29	11	40
328	....do	2.60	....do	3.7	.0	.0	26	0	26
329	....do	3.10	....do	.0	.0	.0	0	0	0
330	....do	4.20	....do	.0	.0	.0	0	0	0
385	Dec. 16, 1910	3.20	....do	.0	.0	.0	0	0	0
387	....do	2.30	....do	.0	.0	.0	0	0	0
388	....do	2.20	....do	.3	.7	1.3	7	21	28
389	....do	1.40	....do	.0	2.1	.3	15	5	20

MUSSEL GULLY.

Mussel Gully lies northwest of Little Dauphin Island, running northeast from Turtle Hole and ending blindly in a sand flat. The beds which bear its name, as considered in this report, lie between the gully and the island. They are of no importance and are badly infested with drills.

The following tables furnish all necessary information:

OYSTER GROWTH IN MUSSEL GULLY.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Very scattering	11	123	27	1,353	297	1,650
Depleted	32	51	0	1,632	0	1,632
Total	43	....	....	2,985	297	3,282

DETAILS OF EXAMINATION OF MUSSEL GULLY.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
393	Dec. 16, 1910	1.00	Very scattering	6.1	11.4	1.7	123	27	150
395	do	1.00	Depleted	.0	7.3	.0	51	0	51

SAND REEF.

This bed lies in Mobile Bay, stretching from Redfish Gully to Pass Drury for a distance of about 2½ miles along the outside of Little Dauphin Island. It has an average width of about one-third mile from above low-water mark to a depth of about 10 feet. It is the largest bed falling within the limits of this report, but at the time of examination it was of comparatively little economic value, and at no time were boats observed at work on it. Its extent, the distribution of oyster growth, and content of oysters are shown in the following table:

OYSTER GROWTH ON SAND REEF.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	220	108	318	23,760	69,960	93,720
Scattering	185	61	98	11,285	18,130	29,415
Very scattering	21	38	40	798	840	1,638
Depleted	229	7	4	1,603	916	2,519
Total	655			37,446	89,846	127,292

The dense growth covers a nearly continuous strip running the entire length of the bed. The oysters occur in rather large clusters and are of medium size, with comparatively few over 4 inches long, and inferior in shape and quality. The scattering growth lies principally inshore of the upper or northeast half of the dense area, extending well up to or above low-water mark. The oysters lie in clusters and are apparently tossed about by the waves and often more or less submerged in the sand. The very scattering growth fringes the offshore edge of the upper third of the dense area. The depleted bottom, which is the most extensive of the four classes of oyster growth represented, lies mainly in a large body in the half of the bed close to the mouth of the bay. The oysters on this bed probably rarely, if ever, become fit for market, and are of value as seed only, and even for such purposes they should be used with caution, owing to the danger of transplanting the drills which abound.

The following examinations were made:

DETAILS OF EXAMINATION OF SAND REEF.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
127	Nov. 23, 1910	4.00	Dense	5.9	3.3	11.1	64	178	242
128	....do	4.50	....do	.0	3.7	17.8	21	285	306
131	....do	5.00	....do	2.4	8.1	12.4	74	198	272
132	....do	5.00	....do	3.8	5.7	14.3	66	229	295
133	....do	4.50	....do	2.2	5.5	13.3	54	213	267
135	....do	4.50	....do	.0	12.6	11.9	88	190	278
136	....do	4.00	....do	11.1	8.9	30.0	140	480	620
137	....do	4.00	....do	1.5	5.2	25.2	47	404	451
139	....do	5.00	....do	8.6	21.0	33.8	207	540	747
142	....do	5.00	....do	4.3	11.4	24.3	110	389	499
143	....do	5.75	....do	2.8	5.0	14.4	55	230	285
196	Nov. 24, 1910	3.00	....do	4.5	8.4	10.0	90	160	250
197	....do	3.00	....do	1.6	4.2	14.9	41	238	279
198	....do	2.90	....do	(a)	13.6	16.2	(a)	259	....
201	....do	4.25	....do	16.0	8.1	13.3	169	213	382
148	Nov. 23, 1910	4.00	....do	2.6	9.6	13.7	85	219	304
149	....do	5.50	....do	7.9	19.5	25.8	192	413	605
150	....do	7.00	....do	10.0	14.7	25.3	173	405	578
152	....do	7.00	....do	2.0	16.7	36.0	131	576	707
153	....do	5.00	....do	8.6	18.1	29.5	187	472	659
154	....do	5.00	....do	4.3	27.2	33.4	220	535	755
194	Nov. 24, 1910	7.00	....do	4.8	9.6	10.7	101	171	272
205	....do	3.40	....do	1.3	7.1	10.3	59	165	224
207	....do	4.00	....do	1.5	9.2	10.4	75	167	242
209	....do	4.00	....do	1.1	19.7	38.2	146	614	760
195	....do	3.00	Scattering	3.5	4.2	6.8	54	109	163
140	Nov. 23, 1910	4.50	....do	15.6	5.6	8.9	148	142	290
144	....do	8.00	....do	1.7	23.9	5.0	179	80	259
199	Nov. 24, 1910	2.80	....do	.6	1.3	1.3	13	21	34
200	....do	2.75	....do	.0	4.2	6.1	29	98	127
202	....do	3.50	....do	3.2	9.0	7.1	92	114	206
206	....do	2.50	....do	.0	.3	6.8	2	109	111
208	....do	2.50	....do	.0	2.5	9.0	17	144	161
210	....do	2.80	....do	.0	2.6	4.2	18	67	85
147	Nov. 23, 1910	6.00	Very scattering	.6	1.1	1.7	12	27	39
151	....do	8.00	....do	.0	1.3	.0	72	0	72
155	....do	6.00	....do	.0	.0	4.4	0	72	72
204	Nov. 24, 1910	3.00	....do	3.2	6.5	3.9	68	62	130
115	Nov. 23, 1910	6.00	Depleted	.0	.0	.0	0	0	0
116	....do	6.00	....do	.0	.0	.0	0	0	0
117	....do	9.00	....do	.0	.0	.0	0	0	0
118	....do	8.00	....do	1.3	.0	.0	9	0	9
119	....do	6.00	....do	1.3	.0	.0	9	0	9
120	....do	5.50	....do	.0	.0	.0	0	0	0
121	....do	5.00	....do	.0	.0	.0	0	0	0
122	....do	6.00	....do	.0	.0	.0	0	0	0
123	....do	5.25	....do	.5	1.0	.5	10	8	18
124	....do	9.50	....do	.0	.0	.0	0	0	0
125	....do	5.25	....do	.5	.0	.0	3	0	3
126	....do	4.50	....do	.4	.4	.7	6	11	17
129	....do	5.00	....do	.0	.0	2.4	0	38	38
130	....do	6.00	....do	.0	.0	.0	0	0	0
134	....do	5.50	....do	.0	.0	.0	0	0	0
138	....do	6.50	....do	.0	1.7	.0	12	0	12
141	....do	7.50	....do	.6	.0	.0	4	0	4
146	....do	7.00	....do	2.0	3.3	.0	37	0	37
203	Nov. 24, 1910	2.50	....do	3.2	3.2	1.0	45	16	61

[a] Many.

DAUPHIN ISLAND BAY.

Practically the entire bottom of this bay is sparsely covered with oyster growth, but in only a few patches in the southeastern half is the growth sufficiently productive to warrant tonging.

The area and character of oyster growth and the estimated content of oysters in the bay are shown in the table following.

OYSTER GROWTH IN DAUPHIN ISLAND BAY.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Scattering	52	49	104	2,548	5,408	7,956
Very scattering	154	25	45	3,850	6,930	10,780
Depleted	550	48	3	26,400	1,650	28,050
Total	756			32,798	13,988	46,786

There are three areas of what this report designates as scattering oysters, one of about 6 acres close to the Dauphin Island shore, and two larger ones near Little Dauphin Island. It is stated that oysters are planted or bedded in the bay, and it is possible that some of the bottom included in the foregoing is not wholly natural bed.

Included between these three patches is a considerable area of very scattering growth. The depleted bottom lies around the shores south and west of the preceding and in the entire northwestern part of the bay where there are practically no market oysters and but a limited quantity of small ones.

The oysters in practically all parts of the bay were poor in shape and quality. Some drills were found and many dead small oysters.

DETAILS OF EXAMINATION OF DAUPHIN ISLAND BAY.

Angle No:	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
222	Dec. 5, 1910	1.50	Scattering	0.0	3.6	7.7	25	123	148
225	do	1.80	do	.0	3.0	8.6	21	138	159
213	do	2.00	do	.0	3.0	6.3	21	101	122
229	do	6.00	do	.0	12.2	6.1	85	98	183
230	do	4.00	do	4.6	2.3	.8	48		48
231	do	4.00	do	1.2	11.5	5.8	89	93	182
232	do	3.90	do	1.5	6.5	10.8	56	173	229
212	do	2.50	Very scattering	.6	5.6	2.5	44	40	84
214	do	2.50	do	.0	2.8	1.9	20	30	50
215	do	2.00	do	.0	1.5	3.0	11	48	59
216	do	2.50	do	.0	.6	3.1	4	50	54
217	do	3.00	do	.0	.0	2.9	0	46	46
218	do	3.00	do	3.0	5.2	2.6	57	42	99
220	do	2.50	do	.0	4.2	2.8	29	45	74
221	do	1.50	do	.0	1.8	4.5	13	72	85
226	do	2.00	do	.8	3.8	4.3	32	69	101
227	do	3.00	do	.0	3.2	1.9	22	30	52
233	do	4.00	do	1.9	4.2	2.3	43	37	80
219	do	3.00	Depleted	.0	6.5	1.0	46	16	62
223	do	.50	do	.0	2.8	1.1	20	18	38
224	do	.50	do	.0	.0	.0	0	0	0
228	do	4.00	do	.0	3.5	.8	25	13	38
234	do	4.00	do	7.3	6.1	.4	94	6	100
235	do	4.50	do	.0	.0	.0	0	0	0
236	do	4.00	do	.8	1.9	.4	19	6	25
237	do	3.00	do	10.7	12.0	1.0	160	16	176
238	do	4.00	do	5.8	3.5	1.2	65	19	84
344	Dec. 15, 1910	.90	do	.0	.0	.0	0	0	0
345	do	1.20	do	3.1	24.4	.0	193	0	193
346	do	2.30	do	3.9	1.0	.0	34	0	34
347	do	2.30	do	1.9	1.0	.0	20	0	20
348	do	1.00	do	2.5	4.7	.0	51	0	51
349	do	1.30	do	.0	4.2	.0	29	0	29
350	do	2.30	do	1.0	1.3	.0	16	0	16

Details of Examination of Dauphin Island Bay—Continued.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
351	Dec. 15, 1910	3.30	Depleted	2.0	10.8	0.5	90	8	98
352	do	1.00	do	1.4	16.9	.0	128	0	128
353	do	2.10	do	4.5	5.8	.3	72	5	77
354	do	1.00	do	1.9	7.2	.3	64	5	69
355	do	1.40	do	1.8	5.5	.3	51	5	56
356	do	4.00	do	4.0	2.5	.0	46	0	46
357	do	4.00	do	.5	8.5	.0	70	0	70
358	do	5.00	do	.0	.0	.0	0	0	0
359	do	4.50	do	5.0	3.9	.6	62	10	72
360	do	4.80	do	7.5	3.8	.0	79	0	79
361	do	3.60	do	.0	.3	.0	2	0	2
362	do	1.00	do	.0	3.6	.0	25	0	25
363	do	1.30	do	.6	8.3	.0	62	0	62
364	do	4.30	do	.0	3.0	.0	21	0	21
365	do	3.40	do	1.4	2.3	.0	27	0	27
367	do	4.20	do	.0	1.5	.0	11	0	11
368	do	5.30	do	.0	.0	.0	0	0	0
369	do	3.10	do	6.2	11.2	.0	122	0	122
370	do	4.10	do	7.5	5.0	.0	87	0	87
371	do	5.10	do	.0	.0	.0	0	0	0
372	do	5.60	do	.0	4.0	.0	28	0	28
373	do	3.50	do	.0	2.3	.0	16	0	16
375	do	5.50	do	4.0	.0	.0	28	0	28
376	do	5.50	do	2.0	.7	.0	19	0	19
377	do	5.40	do	6.0	6.0	.0	84	0	84
378	do	3.70	do	8.2	.9	.5	64	8	72
379	do	3.10	do	7.1	1.3	.0	59	0	59
380	do	5.50	do	.0	.0	.0	0	0	0

SPRINKELS BAY.

There are practically no market oysters in this bay, but small ones in clusters are scattered over the bottom. There were many dead oysters at the time of examination. The following tables exhibit all that it is necessary to say concerning this region:

Oyster Growth in Sprinkels Bay.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Depleted	133	60	1	7,980	133	8,113

Details of Examination of Sprinkels Bay.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
366	Dec. 15, 1910	1.10	Depleted	0.0	17.0	0.3	119	5	124
374	do	3.00	do	2.9	4.2	.0	50	0	50
396	Dec. 16, 1910	1.00	do	.3	13.6	.3	97	5	102
397	do	3.00	do	1.3	.0	.0	9	0	9
398	do	1.00	do	.0	3.9	.0	27	0	27
399	do	2.00	do	1.6	13.6	.0	106	0	106
400	do	1.10	do	.0	.0	.0	0	0	0
401	do	3.00	do	4.5	5.4	.0	69	0	69

COLLIER BAY.

The oysters here, which are practically all small, are scattered in clusters along most of the shore of the bay. The bottom is mainly soft mud, with considerable grass in places. The percentage of dead spat and small oysters is large. The following tables give the data obtained in this bay:

OYSTER GROWTH IN COLLIER BAY.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Depleted	13	57	2	741	26	767

DETAILS OF EXAMINATION OF COLLIER BAY.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
407	Dec. 16, 1910	1.00	Depleted	0.0	5.3	0.3	37	5	42
408	do	3.00	do	.0	.8	.0	6	0	6
409	do	1.20	do	.0	18.3	.0	128	0	128

OFF EAST BASE SIGNAL.

This is a very small patch on a point west of Collier Bay, which among considerable débris contains a few scattering clusters of four or five small sharp-edged oysters each.

OYSTER GROWTH OFF EAST BASE SIGNAL.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Depleted	3	3	0	9	0	9

DETAILS OF EXAMINATION OF POINT OFF EAST BASE SIGNAL.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
405	Dec. 16, 1910	1.00	Depleted	0.8	0.0	0.0	6	0	6
406	do	1.00	do	.0	.0	.0	0	0	0

HALF-MOON PATCHES.

This name, which is not used by the oystermen, serves to designate a number of small areas of oyster growth lying west of the lower end of Cedar Point. Most of these patches are not more than an acre or two in extent and bear scattering growth or are depleted. They generally lie on a soft muddy bottom, but there is a hard reef on which the water shoals to a minimum of 1½ feet about 500 or 600 yards west of the extreme end of Cedar Point.

The following tables exhibit the area and condition of these patches.

OYSTER GROWTH ON HALF-MOON PATCHES.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	2	8	154	16	308	324
Very scattering	8	13	55	104	440	544
Depleted	4	60	0	240	0	240
Total	14			360	748	1,108

DETAILS OF EXAMINATION OF HALF-MOON PATCHES.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
263	Dec. 7, 1910	4.00	Dense				8	154	162
466	Dec. 29, 1910	6.00	Very scattering	0.0	4.3	4.3	31	69	100
465	do	6.00	do	.0	.0	2.9	0	46	46
464	do	5.00	do	.0	1.2	3.1	8	50	58
462	do	4.50	Depleted	.0	1.7	.0	12	0	12
460	do	4.00	do	3.5	14.5	.0	126	0	126
459	do	3.50	do	1.8	4.1	.0	41	0	41

HERON BAY, EAST SIDE.

On the east side of Heron Bay there is an area of oyster growth stretching along shore for nearly a mile south of the forks of the bay. It consists principally of depleted bottom in which there are shells more or less buried in the mud, with an occasional cluster of oysters. The area and character of the growth on the several parts of this bed are as follows:

OYSTER GROWTH IN HERON BAY, EAST SIDE.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	34	101	190	3,434	6,460	9,894
Scattering	11	13	96	143	1,056	1,199
Very scattering	5	110	72	550	360	910
Depleted	52	0	0	0	0	0
Total	102			4,127	7,876	12,003

There is an area of dense growth at the northern end of the bed, apparently extending on to the planted bottom inside of the northeast arm of the bay. These oysters are in small clusters and are of good size and fair shape and quality. There is another dense patch near the southern end of the bed, where the oysters are smaller and inferior.

The scattering growth lies in a narrow strip along the western edge of the southern half of the bed. The bottom consists in large part of firm mud and shells lying in a substratum of soft mud. The very scattering growth lies in a small patch near the southern inshore part of the bed and the depleted area stretches nearly the entire length of the bed and for a considerable distance comprises its entire width. The following examinations were made:

Details of Examination of Heron Bay, East Side.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
507	Jan. 1, 1911	3.0	Dense	2.1	16.3	14.2	129	227	356
508	.....do	4.9	.....do	.0	11.2	10.0	78	160	238
516	.....do	4.0	.....do	.0	13.5	11.5	95	184	279
418	Dec. 21, 1910	4.0	Scattering	.5	.0	5.0	4	80	84
515	Jan. 1, 1911	4.3	.....do	.0	3.0	7.0	21	112	133
417	Dec. 21, 1910	3.6	Very scattering	.0	15.8	4.5	110	72	182
416	.....do	3.6	Depleted	.0	.0	.0	0	0	0

HERON BAY, WEST SIDE.

The oyster growth on the western, or, more accurately, on the northwestern, side of Heron Bay stretches along shore for a distance of upward of one-half mile from the mouth of northwest arm.

The following table exhibits the area, density of oyster growth, and estimated total content of oysters:

Oyster Growth in Heron Bay, West Side.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	31	54	245	1,674	7,595	9,269
Depleted	21	4	10	84	210	294
Total	52			1,758	7,805	9,563

The area of dense growth lies at the northeast end of the bed on a very hard sand and shell bottom, gradually becoming softer toward the depleted bottom. The oysters are elongated, sharp edged, and in rather heavy clusters, bearing a few mussels.

The depleted bottom consists partly of soft mud, partly sand, and in places 3 inches of the former overlying a substratum of the latter. The following examinations were made on this bed.

DETAILS OF EXAMINATION OF HERON BAY, WEST SIDE.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
504	Jan. 1, 1911	3.2	Dense	0.0	6.2	15.0	44	240	284
509	....do	3.4	....do	.0	15.9	20.9	111	334	445
510	....do	3.1	....do	.0	.8	10.0	6	160	166
514	....do	4.5	Depleted	.0	.6	.6	4	10	14

Lying in the middle of Heron Bay is a long, narrow bed of planted oysters, continuous at its northern end with what appears to be a natural scattering growth. It is probable that this whole area is on an old bed.

HERON BAY, NORTHWEST ARM.

It was understood that the northeastern arm of Heron Bay is comprised within the limits of private ownership, is used for purposes of oyster culture, and contains no public beds. For that reason it was not examined. Northwest Arm is public bottom, but contains very few oysters of value. The following table shows the area, density of oyster growth, and total contents:

OYSTER GROWTH IN HERON BAY, NORTHWEST ARM.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Scattering	16	40	119	640	1,904	2,544
Depleted	42	10	17	420	714	1,134
Total	58			1,060	2,618	3,678

The area of scattering growth lies as a strip along shore at the eastern side of the mouth of the arm. The market oysters on this area are rather large and some of them of good shape and quality. The depleted bottom stretches from shore to shore in the upper part and continues as a strip along the western shore in the lower half of the arm. The oysters, of which a fair proportion are of good size, lie in clusters on a bottom of soft or very soft mud in which there are many buried shells. The indications are that this body of water would produce good oysters if a firm surface could be provided by the use of sand and shells.

The following observations were made:

DETAILS OF EXAMINATION OF NORTHWEST ARM, HERON BAY.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
502	Jan. 1, 1911	1.8	Scattering	0.0	10.0	7.8	70	125	195
505	....do	4.2	....do	.0	1.5	7.0	10	112	122
498	....do	1.9	Depleted	.0	.9	.0	6	0	6
499	....do	1.5	....do	.0	1.2	1.5	8	24	32
501	....do	1.8	....do	.0	2.3	1.6	16	26	42

MIDDLE GROUND, FOWL RIVER BAY.

This consists of a small reef of dense growth, with an area of very scattered oysters extending from it toward the head of the bay. The area shown in the following table includes in addition that portion of what appears to be a private bed more than 600 yards from the shore.

The area, density of oyster growth, and estimated contents are shown in the following tables:

OYSTER GROWTH IN MIDDLE GROUND, FOWL RIVER BAY.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	12	93	204	116	2,448	2,564
Very scattering	40	107	58	4,280	2,320	6,600
Total	52			4,396	4,768	9,164

DETAILS OF EXAMINATION OF MIDDLE GROUND, FOWL RIVER BAY.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
637	Jan. 11, 1911	4.0	Dense	0.0	9.5	14.5	66.5	232.0	298.5
640	....do	4.3	....do	.0	17.0	11.0	119.0	176.0	295.0
638	....do	3.5	Very scattering	.0	19.0	2.7	133.0	43.2	176.2
639	....do	4.0	....do	1.5	10.0	4.5	80.5	72.0	152.5

GRASSY ISLAND.

This is a small patch running from the north side of Grassy Island to a depth of about 1 foot. It is apparently an old bar, but is at present of very little value, as is shown in the following table:

OYSTER GROWTH ON GRASSY ISLAND.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Depleted	4	10	13	40	52	92

DETAILS OF EXAMINATION OF GRASSY ISLAND.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
683	Jan. 13, 1911	0.8	Depleted	0.0	1.4	0.8	9.8	12.8	22.6

GOOSE BAYOU.

This bed, consisting of a small area of dense growth, almost surrounded by very scattering oysters, is apparently included within a private claim, although there is no doubt that it is an old natural bed. There is a considerable proportion of large oysters of good shape. The area, character of oyster growth, and estimated content of the bed are as follows:

OYSTER GROWTH IN GOOSE BAYOU.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	5	76	286	380	1,430	1,810
Very scattering	7	406	51	2,842	357	3,199
Total	12			3,222	1,787	5,009

DETAILS OF EXAMINATION OF GOOSE BAYOU.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
669	Jan. 12, 1911	1.5	Dense	0.0	10.9	17.9	76.3	286.4	362.7
671	do	1.2	Very scattering	2.2	7.6	2.8	68.6	44.8	113.4
672	do	1.5	do	.0	1.8	3.6	12.6	57.6	70.2

SOUTHWEST OF VAN SIGNAL.

This is a small patch of dense growth about 300 yards from shore. The oysters have a good shape, most of them are single, and at the time of examination were fat. Drills or borers were noted on the bed. The following tables show the results of the examination:

OYSTER GROWTH SOUTHWEST OF VAN SIGNAL.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	1	70	560	70	560	630

DETAILS OF EXAMINATION SOUTHWEST OF VAN SIGNAL.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
664	Jan. 12, 1911	3.0	Dense	3.3	6.7	35.0	70	560	630

EAST SIDE OF MARSH ISLAND.

About 300 yards from the island is a small patch of depleted bottom. Its condition is shown in the following tables:

OYSTER GROWTH ON EAST SIDE OF MARSH ISLAND.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Depleted	2	52	6	104	12	116

DETAILS OF EXAMINATION OF EAST SIDE OF MARSH ISLAND.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
651	Jan. 11, 1911	2.4	Depleted	0.0	7.4	0.4	51.8	6.4	58.2

PORTERSVILLE BAY, STATE-PLANTED BED.

This bed is said to have been planted in June, 1910, and it was examined by the survey party on January 11, 1911. The bottom was of a consistency rated in this report from stiff to soft. The oysters were found to be growing in dense clusters and were fit for steaming only. They were evidently planted too thickly and irregularly to secure the best results, and apparently the clusters were not broken up. If they had been separated so as to give the individual oysters room for growth, they would have produced much better and more valuable stock. It is said that the seed oysters, when planted, were about $1\frac{1}{2}$ inches long. When examined six months later, 40 per cent were between 1 and 3 inches long, 40 per cent between 3 and 4 inches, and 20 per cent over 4 inches.

The experiment indicates that if oysters be planted in this region in accordance with the best practice the results should be excellent.

The following tables exhibit the general condition of this bed:

OYSTER GROWTH IN PORTERSVILLE BAY (STATE-PLANTED BED).

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	8	250	472	2,000	3,776	5,776

DETAILS OF EXAMINATION OF PORTERSVILLE BAY, STATE-PLANTED BED.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
625	Jan. 11, 1911	4.3	Dense	1.0	45.5	25.0	315.5	400.0	715.5
626	.....do	4.0	.....do	1.5	25.0	34.0	185.5	544.0	729.5

PORTERSVILLE BAY, NORTH END.

This is a small bed of very scattering growth, about 700 yards from the north shore of the bay. It is probable that there may be other insignificant patches in the vicinity. The character of the bed is sufficiently indicated by the following tables:

OYSTER GROWTH IN PORTERSVILLE BAY, NORTH END.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Very scattering	2	122	57	244	114	358

DETAILS OF EXAMINATION OF PORTERSVILLE BAY, NORTH END.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
		Feet.					*Bush.*	*Bush.*	*Bush.*
592	Jan. 10, 1911	6.0	Very scattering....	2.8	7.0	2.8	68.6	44.8	113.4
593	.....do.......	6.0	.....do.............	5.7	19.3	4.3	175.0	68.8	243.8

WEST SIDE OF COFFEE ISLAND.

Along a considerable part of the southern half of the west shore of Coffee Island is a fringe of depleted bottom. It is stated that this was at one time moderately productive, but there is but an occasional scattered cluster of oysters to be found at present, and their distribution was so irregular that it was not possible to arrive at an estimate of their quantity. This narrow fringe of bottom is useful for planting but valueless for oyster producing in its natural state.

THE BEDS IN SUMMARY.

Within the limits of this survey the natural beds are confined to two general regions—(*a*) Mobile Bay and Mississippi Sound adjacent to their junction and (*b*) in Portersville Bay and vicinity. It is stated that formerly there were oysters in Grand Bay, where none or practically none exist at present, and recently a bed was reported in the open sound, somewhere south of Grand Bay near the State line. If the latter exist, it can not be of much importance, as a search as careful as the circumstances seemed to warrant failed to reveal it. There are a few scattered clusters of oysters close to shore on the west side of Coffee Island, but they are not worthy of consideration as natural growth.

The contiguous parts of Mobile Bay and Mississippi Sound contain by far the most extensive and productive oyster beds in the State. As is shown on the chart, there extends from Buoy Reef to Pass Drury a practically continuous area of dense and scattering growth flanked, especially toward the sound, by very scattering oysters and depleted bottom. These beds, including Kings Bayou Reef and Heron Bay, cover a total area of 3,900 acres, of which 1,451 acres bear dense, 501 acres scattering, and 436 acres very scattering growth, while 1,512 acres are classed as depleted.

The depth of water over these beds is slight and, excepting the passes and gullies, remarkably uniform, ranging generally between 1 and 4 feet. On Buoy and Kings Bayou Reefs the depth is a few feet greater, as is shown on the chart.

The remaining beds, which are confined to Portersville Bay and vicinity, contain but about 108 acres, part of which appears to lie

within private claims. In addition to this there are what appear to have been natural beds, lying in less than 2 feet of water, between Cat Island, Murder Point, and the mouth of Goose Bayou, most of which are now planted or claimed as planted.

The entire area of 4,008 acres of natural beds surveyed embraces 37 per cent of dense growth, 13 per cent of scattering, 12 per cent of very scattering, and 38 per cent of depleted bottom. This distribution is summarized in the following table:

SUMMARIZED STATEMENT OF AREAS OF MARKET OYSTERS ON PUBLIC BEDS.

Name of bed.	Character of oyster growth.				Total.
	Dense.	Scattering.	Very scattering.	Depleted.	
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Kings Bayou Reef	39		40	3	82
Buoy Reef	202	34	19	12	267
Cedar Point Reef	100	21	24	56	201
Pass des Huitres	53	30			83
Pass des Huitres Flats	122	41	39		202
Dutch Gully	39	19			58
Dutch Island	42	21		24	87
Big Gully	44	10		11	65
Peter Billys Gully	39		14	28	81
Grants Pass	64	21		42	127
Pass aux Herons	211	14	43	24	292
Redfish Gully	209	11			220
Black Lumps		13	49	77	139
West side Little Dauphin Island			9	156	165
Mussel Gully			11	32	43
Sand Reef	220	185	21	229	655
Dauphin Island Bay		52	154	550	756
Sprinkels Bay				133	133
Collier Bay				13	13
East Base				3	3
Half-moon Patches	2		8	4	14
Heron Bay, east side	34	11	5	52	102
Heron Bay, west side	31	2		21	54
Northwest arm Heron Bay		16		42	58
Middle Ground	12		40		52
Grassy Island				4	4
Goose Bayou	5		7		12
Southwest Van signal	1				1
East of Marsh Island				2	2
Planted oysters, Portersville Bay	8				8
North end Portersville Bay			2		2
West side Coffee Island				27	27
Total	1,477	501	485	1,545	4,008

It should be understood that the foregoing classification in respect to relative density of oyster growth is based solely on the quantity of oysters 3 inches or more in length, irrespective of the quantity of small oysters present. The classification furthermore represents the condition at the time of examination and the several classes may, and undoubtedly will, undergo redistribution from time to time. The areas of dense growth may become less productive from overfishing or other causes, while a heavy set of spat may bring the lower classes into increased productivity and raise them a step higher in the scale. In some cases the number of young oysters on the beds at the time of examination was sufficient to produce this effect in the following year. On the whole, however, the general conditions shown in this report, barring accidents, should be main-

tained for a period of years. The estimated total content of oysters on the several parts of the different beds is shown in the following table:

SUMMARIZED CONTENT OF MARKET OYSTERS ON PUBLIC BEDS.

Name of bed.	Character of oyster growth.				Total.
	Dense.	Scattering.	Very scattering.	Depleted.	
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Kings Bayou Reef	9,126	....	3,640	18	12,784
Buoy Reef	65,448	3,672	1,178	48	70,346
Cedar Point Reef	34,000	2,730	984	0	37,714
Pass des Huitres	16,059	2,760	....	....	18,819
Pass des Huitres Flats	37,088	5,699	1,794	....	44,581
Dutch Gully	9,867	1,919	....	....	11,786
Dutch Island	11,718	2,079	....	312	14,109
Big Gully	13,640	800	....	0	14,440
Peter Billys Gully	9,555	....	532	168	10,255
Grants Pass	22,976	2,352	....	924	26,252
Pass aux Herons	109,720	1,316	2,279	96	113,411
Redfish Gully	65,417	880	....	....	66,297
Black Lumps	....	1,807	2,401	231	4,439
West side Little Dauphin Island	....	....	315	624	939
Mussel Gully	....	....	297	0	297
Sand Reef	69,960	18,130	840	916	89,846
Dauphin Island Bay	....	5,408	6,930	1,650	13,988
Sprinkels Bay	....	....	....	60	60
Collier Bay	....	....	....	26	26
East Base	....	....	....	0	0
Half-moon Patches	308	....	440	0	748
Heron Bay, east side	6,460	1,056	360	0	7,876
Heron Bay, west side	7,595	284	....	210	8,089
Northwest arm Heron Bay	....	1,904	....	714	2,618
Middle Ground	2,448	....	2,320	....	4,768
Grassy Island	....	....	....	52	52
Goose Bayou	1,430	....	357	....	1,787
Southwest Van signal	560	....	....	....	560
East of Marsh Island	....	....	....	12	12
Planted oysters, Portersville Bay	3,776	....	....	....	3,776
North end Portersville Bay	....	....	114	....	114
West side Coffee Island	....	....	....	0	0
Total	497,151	52,796	24,781	6,061	580,789

Of the total it is estimated that the beds lying in the contiguous parts of Mobile Bay and Mississippi Sound bear over 98 per cent, or 569,720 bushels, of which 488,937 bushels occur as dense growth, 52,796 bushels as scattering, 21,990 bushels as very scattering, and but 5,997 bushels on the so-called depleted bottom. It will be seen from this that the depleted bottom and even the areas of very scattering growth bore a wholly insignificant crop of oysters at the time of examination. The present negligible character of these two classes, and especially the lowest, regarded as naturally productive beds, is still more plainly seen by a comparison of their content per acre with that of the areas of dense and scattering growth.

Considering as a whole all of the beds examined in the State, aggregating 4,008 acres, the areas classed as dense bore an average of 336 bushels of oysters of market size per acre, the scattering 105 bushels, very scattering 51 bushels, and the depleted but 4 bushels. It should be stated that for the more prolific growths the averages probably understate the truth, while for the very scattering and depleted growths they are approximately accurate. On very rank growth the

tongs will not always take up all oysters within their grasp, and as the foregoing estimates are based primarily on the area of bottom covered by a "grab" and the number of oysters taken therein, the actual density of growth is somewhat greater than shown. Where the oysters do not lie so thickly this is not true.

On some of the beds, notably Buoy Reef, Grants Pass, Pass aux Herons, and Redfish Gully, oystering had been carried on for a month or two prior to the examination, and the survey therefore disclosed fewer oysters than had been on the beds at the beginning of the season. Moreover, the bushel as measured by the survey party contains probably at least 30 per cent more oysters than the ordinary market bushel, as to secure uniformity in the case of the former the oysters are culled and the clusters broken to singles and doubles and carefully packed in the measure.

Of less immediate importance, but greater potential significance than the marketable oysters, are the young ones. Upon them depends the future of the fishery. A bed with a large number of healthy young, not unduly subject to accident, is an asset of more value than a bed of old oysters whose future is imperiled by a deficiency of spat. That in this respect the principal beds covered by the survey are in good condition is shown by the following table:

SUMMARIZED CONTENT OF YOUNG OYSTERS ON PUBLIC BEDS.

Name of bed.	Character of oyster growth.				Total.
	Dense.	Scattering.	Very scattering.	Depleted.	
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Kings Bayou Reef	11,544		8,200	324	20,068
Bayou Reef	42,218	5,610	1,444	348	49,620
Cedar Point Reef	14,000	2,541	864	4,984	22,389
Pass des Huitres	19,345	6,390			25,735
Pass des Huitres Flats	36,112	5,371	1,014		42,497
Dutch Gully	8,034	4,218			12,252
Dutch Island	13,524	6,258		3,960	23,742
Big Gully	12,496	2,770		0	15,266
Peter Billys Gully	12,636		560	0	13,196
Grants Pass	17,600	3,339		2,940	23,879
Pass aux Herons	49,163	448	3,354	360	53,325
Redfish Gully	48,279	286			48,565
Black Lumps		1,820	6,664	1,078	9,562
West Side Little Dauphin Island			522	1,404	1,926
Mussel Gully			1,353	1,632	2,985
Sand Reef	23,760	11,285	798	1,603	37,446
Dauphin Island Bay		2,548	3,850	26,400	32,798
Sprinkels Bay				7,980	7,980
Collier Bay				741	741
East Base				9	9
Half-Moon Patches	16		104	240	360
Heron Bay, east side	3,434	143	550	0	4,127
Heron Bay, west side	1,674	118		84	1,876
Northwest Arm, Heron Bay		640		420	1,060
Middle Ground	116		4,280		4,396
Grassy Island				40	40
Goose Bayou	380		2,842		3,222
Southwest Van signal	70				70
East of Marsh Island	104				104
Planted oysters, Portersville Bay	2,000				2,000
North end, Portersville Bay			244		244
West Side, Coffee Island				0	0
Total	316,505	53,785	36,643	54,547	461,480

It will be observed by comparing this table with that showing the content of market oysters that certain beds, such as Kings Bayou, Pass des Huitres, Dutch Island, etc., bear a quantity of small oysters in excess of those of marketable size. On other beds, particularly those like Bayou Reef, Pass aux Herons, etc., which have been most worked, the contrary is the case, the small being quantitatively less than the large. The reasons for this difference, particularly striking in view of the loss of large oysters which Bayou Reef, Pass aux Herons, and similar beds sustain through the fishery, may differ with the beds concerned. It is probable that Kings Bayou Reef, from its location, feels the effects of freshets, and many of the oysters are killed before they reach a large size, leaving a preponderance of young. On other beds the oysters are so densely crowded as to leave but little room for growth, or they may be disadvantageously situated with respect to the food supply, and the small oysters are stunted specimens rather than young. This fact is of some importance when the oysters are used as seed, for stunted oysters generally grow less rapidly than normal young when transplanted to places where the growing conditions are more favorable.

In considering the adequacy of the small oysters to maintain the future supply of marketable oysters, the measured quantity is misleading, owing to the difference in bulk of individuals at different ages. The significant real condition is the numerical relationship which is shown in the following table:

NUMBER OF OYSTERS UNDER 3 INCHES LONG FOR EACH ONE OVER THAT LENGTH ON THE SEVERAL BEDS.

Name of bed.	Character of oyster growth.			
	Dense.	Scattering.	Very scattering.	Depleted.
Kings Bayou Reef	2.89		5.17	38.50
Buoy Reef	1.47	3.49	2.82	No small.
Cedar Point Reef	.94	2.12	2.06	No large.
Pass des Huitres	2.99	5.29		
Pass des Huitres Flats	2.21	2.14	1.24	
Dutch Gully	1.70	4.98		
Dutch Island, west side	2.55	6.86		29.50
Big Gully	2.08	7.92		No small.
Peter Billys Gully	3.02		2.37	No small.
Grants Pass	1.75	3.25		7.10
Pass aux Herons	1.02	7.74	3.35	8.66
Redfish Gully	1.63	.73		
Black Lumps		2.30	6.42	12.07
West Side Little Dauphin Island			3.77	4.74
Mussel Gully			10.29	No large.
Sand Reef	.77	1.42	1.27	4.22
Dauphin Island Bay		1.07	1.23	35.33
Sprinkels Bay				113.83
Collier Bay				81.33
East Base				No large.
Half-Moon Patches	.11		.53	No large.
Heron Bay, east side	1.20	.29	3.51	No small.
Heron Bay, west side	.50			1.00
Northwest Arm, Heron Bay		.84		1.42
Middle Ground	1.04		4.24	
Grassy Island				1.75
Goose Bayou	.61		1.81	
Southwest Van signal	.29			
East of Marsh Island				18.50
Planted oysters, Portersville Bay	1.23			
North end, Portersville Bay			4.90	
West side, Coffee Island				No small.

It will be seen from this table that there is a considerable numerical preponderance of small over large oysters practically everywhere, excepting on the dense parts of Buoy, Grants Pass, Pass aux Herons, and Redfish Gully beds, which at present sustain the principal fishery in the region. On all of these the proportion of small to large oysters is less than 2 to 1, and on Pass aux Herons bed they are in approximately equal numbers.

In a region of rapid growth, such as that under consideration, it may be assumed that most, if not all, of the oysters under 3 inches long in January will measure more than that length in the following winter. Leaving out of consideration the question of mortality, the death rate among the oysters during the year in which they were progressing from the small to the market size, a bed on which during the winter there is one oyster under 3 inches for every one over that length should be in no immediate danger of depletion, provided the culling laws be observed. As a matter of fact, however, some of these oysters will die during the year and the rate of death will depend on the local conditions and the degree to which the beds are exposed to enemies and physical perils. There was disclosed during the survey no evidence of serious mortality from oyster enemies or other cause on the beds in the vicinity of Grants Pass, and it may be with safety assumed that young oysters of the sizes found in January will not suffer a greater average mortality than about 30 to 40 per cent within the year, unless subjected to freshets or other accidents. This estimate would fix the minimum requirement of young oysters to maintain the present productiveness of the beds at 1½ for each market oyster present, or more accurately, for each one removed from the beds by death or by the fishery.

As all of the market oysters can not be taken, it is apparent that none of the beds, with the possible exception of Pass aux Herons, are in immediate danger of depletion. The author does not think that even the excepted bed is threatened by the present extent of the fishery.

In the year ended June 30, 1911, the tongers took from the public beds of Mobile County about 180,000 market bushels, mostly from Grants Pass, Pass aux Herons, and Redfish Gully. This, it will be observed, is considerably less than the estimated content of these beds in January, when a considerable quantity of their product already had been removed. These beds at that time contained about 200,000 bushels of oysters over 3 inches long, or about 265,000 bushels as they are measured for the market.

Practically the only parts of the beds which can be fished with profit at the present time are those which are classed as dense and

scattering, aggregating 1,978 acres, with a total estimated marketable content of about 550,000 bushels of oysters. It is believed that these beds would safely sustain, with a proper observance of the culling laws, an annual yield double the present product of dredges and tongs combined, about 275,000 bushels. Many of the beds would be benefited by a reasonable fishery which would remove part of the oysters now going to waste, and allow room for the remainder to grow and improve. In many places a considerable proportion of the small oysters could be removed to advantage, and there would result a double benefit if they were used as seed on some of the barren bottom now going to waste.

BARREN BOTTOMS.

The area of barren bottoms—that is, those which are not naturally productive of oysters even in small quantities—vastly exceeds that of the natural beds, including in the latter those so-called depleted areas which bear practically nothing. These bottoms are barren mainly because of one character in which they differ from the productive areas, namely, that they are devoid of shells or other objects lying on the surface. They consist of sand or mud of varying degrees of stability and consistency. Oysters, immediately after they develop from the egg, for a brief period swim or float freely in the water, settling to a fixed condition only after they reach a stage of considerable development.[a]

It is not necessary to give more detail to this subject other than to say that at the time at which they are undergoing fixation the oysters are very minute, and a slight film of mud or slime is sufficient to stifle them. During the spawning season these little organisms are present in the water in untold myriads and are precipitated to the bottom in a continuous gentle drizzle of tiny specks. If they fall on an oyster bed they find firm supports on the shells and oysters, attach themselves and grow, but if they fall on the mud or bare sand they die.

The natural beds have been slowly developed on bottom similar to that which surrounds them solely because through some agency there originally lodged on the mud or sand some hard objects to which the young oysters could safely cling. Oysters developing there, and their shells scattered about by the waves, furnished additional places for fixation of new generations of young, with the result that the original growth extended in area and its base became a compact mass of shells and fragments, beneath which can still be found by excavation or probing the original bottom differing in no essential particular from the adjacent barren areas.

[a] For a more extended account, see "Oysters and Methods of Oyster Culture," by H. F. Moore, Bureau of Fisheries, Document 349, which may be obtained by application to the Bureau of Fisheries, Washington, D. C.

All that is required by the barren bottom in order that it may become productive is that its surface should be supplied with hard objects or cultch, either through natural agencies or by the hand of man. The capacity of the bottom to sustain material deposited on it and to maintain it in proper condition to serve as cultch depends largely on its stability and consistency. Moving sands gradually cover objects deposited on their surface and soft mud permits them to sink. It is therefore of prime importance for the oyster culturist to have information concerning the character of the bottom and it was one of the purposes of the survey to supply it.

The methods and the instrument employed have been described in the introductory part of this report and the results attained are shown graphically on the chart. No data concerning the bottom are supplied for that part of Mobile Bay covered by the survey, for the reason that the salinity of the water in that region is subject to such violent reduction by freshets as to interfere with successful oyster culture. The chart does not show all of the places at which the bottom was tested, enough stations only being shown to indicate the characteristics. It will be observed that the bottom in most of the deeper part of the sound is composed of either very soft mud or ooze and is entirely unsuitable for oyster planting. Furthermore, the hard bottom occurring close to the islands which form the south shore is composed principally of sand, which shifts during storms. There is a strip along the boundary between the mud and sand where the two materials are blended in such proportions as to give a fair degree of stability, but the zone is narrow, and in general it may be stated that to plant either in the very soft bottom of the deeper water or the sand of most of the south shore, excepting its extreme eastern end, is to invite disaster.

With these two general regions eliminated there remains practically the north shore alone, of which the areas of bottom sufficiently firm to support oysters and shells are discussed in the following pages. The total area of the tracts containing bottoms suitable for oyster culture in that part of Mississippi Sound within the State is 24,420 acres. It must be understood, however, that within the regions hereafter described there are usually areas of unsuitable bottom irregularly distributed.

NEAR HALF-MOON PATCHES.

This area lies west of the Pass des Huitres beds and south of Half-Moon Patches, covering an area of approximately 400 acres. The bottom consists principally of hard mud in its eastern half, gradually becoming softer toward the west. In places a soft surface 6 to 8 inches deep is underlaid by hard or stiff mud and there are occasional small patches of scattered shells either at the surface or buried. Toward the northern part of the area there are a few clustered oysters.

HERON BAY.

Between the two natural beds lying on the opposite sides of this bay is an area of about 70 acres of muddy bottom ranging from moderately stiff to soft, a considerable part of which could be used for oyster culture. In places the mud holds buried shells.

PORTERSVILLE BAY (INCLUDING FOWL RIVER BAY).

In general, the whole of this bay, with the exception of its northwest quarter, has a bottom sufficiently firm for oyster planting, and even in the excepted area there is good bottom close to the shores. In Fowl River Bay the mud ranges from moderately soft to stiff, but in the southern half of Portersville Bay proper the bottom consists of hard and stiff mud and small patches of sand. In many places the bottom is stratified, a very compact layer underlying from 4 to 8 or 10 inches of less hard material. Between Cat Island and Murder Point there are considerable quantities of oysters, indicated on the chart as private beds. It is estimated that about 5,250 acres of good planting bottom lie within the limits of Portersville and Fowl River Bays, including that held under riparian rights.

SOUTH OF PORTERSVILLE BAY.

From Marsh and Cat Islands a sand spit extends southward for a distance of about 3 miles. In the shoaler part of this toward the islands the bottom is shifting, but about a mile off shore in a depth of from 5 to 9 feet of water there is sufficient mud blended with the sand to give it stability. This area, lying just north of the middle of the sound opposite Marsh Island, covers approximately 1,700 acres.

WEST AND SOUTHWEST OF COFFEE ISLAND.

In this region there is a triangular area with Coffee Island as its base and its apex about 1½ miles to the westward, in which a considerable part of the bottom lies west and southwest of the southern part of the island, where it is composed of mud or a mixture of mud and sand close to shore, while within the limits of riparian control the bottom is generally hard or stiff. The total area included within his triangle is about 2,900 acres.

NORTH END OF COFFEE ISLAND.

This is a nearly semicircular area lying between the mainland and a line running from near the hotel on the north shore of Portersville Bay to a point about 1 mile west of the north end of Coffee Island, and thence to the mouth of Bayou la Battre. In a channel encircling the northern end of the island the bottom is soft, but in most other places it is fairly firm or, near the shores, hard. Most of the good

bottom is within the rights of riparian owners. The total area is about 1,110 acres.

There is some good bottom near the shore in Ile aux Dames Bay, but the middle of the bay is soft.

GRAND BAY.

Practically all of Grand Bay, with the exception of a semicircular area near its mouth, has a hard or moderately hard bottom, which could be utilized with safety for purposes of oyster culture. Near the mouth there is some very soft bottom and the sand bars between which the deep channel passes are composed of unstable material shifting under the influence of the waves. The area of good bottom in the bay is about 5,000 acres.

SOUTH OF GRAND BAY.

Within the boundary formed by a line beginning about one-half mile off Point aux Pins and running south for about 5 miles, thence westerly toward Grand signal, to the State line, thence northward to within about one-half mile of Dunn signal, thence parallel with the shore of Grand Batture for about 2½ miles, and thence to the point of beginning is an area of bottom ranging in general consistence from hard to soft. A considerable part of this is, in its natural state, sufficiently firm to support oysters and shells, and much of the remainder could be rendered suitable at comparatively small expense. This is the largest continuous area of like nature within the limits of the survey, containing 8,000 acres. In places it appears to offer supreme advantages for the growth of market oysters from seed, as it will probably be found that the drill will kill off any undesirable set of spat without attacking the seed.

GENERAL PHYSICAL AND BIOLOGICAL CONDITIONS.

TIDES AND CURRENTS.

Staff tide gauges were established at Grants Pass and at the cannery wharf at Coden. The former was maintained from November 18, 1910, to January 19, 1911, and the latter from January 6 to January 29, 1911. The former was referred to the bench mark established on Grants Island by the United States Engineer's Office, which is described as follows:

> The bench mark is the top of a 2-inch pipe which was driven in the ground, a fence placed around it and filled with concrete to within one-half inch of the top of the pipe. The letters U.S.B.M. were written in the concrete before it set. The bench mark is at the northwest side of and near the keeper's house on Grants Island. It has an elevation of 2.654 feet above mean low tide in Mobile Bay as determined by this office. (J. M. Pratt, Assistant Engineer, United States Engineer's Office, Mobile, Ala., Dec. 10, 1910.)

The top of the bench mark accorded with reading 3.65 on the scale of the staff gauge.

The tides in this region, as in general on the Gulf coast, are small, averaging from 1 to 1½ feet in height, but reaching 2½ feet under certain conditions of wind, etc.

No special observations were made of the velocity of the currents, but in general they are sufficient for the transport of food and water to the oysters in all places covered by the survey.

SALINITY OF THE WATER.

As is well known, the quantity of salt in the water is an important factor in determining the growth and character of oysters. Neither fresh water nor that of full oceanic saltness is suitable for the oyster itself, and, moreover, the degree of saltness often determines the presence, absence, or relative abundance of such oyster enemies as the drill or borer. During the survey upward of 300 specific-gravity observations were made to determine the condition of the water in respect to its content of salt. Three tests were made daily on the *Fish Hawk*, and in addition observations were taken on the oyster beds and in their immediate vicinity. The following table is a summary of all of the ship's observations, supplemented by some of those taken on and near the important natural beds:

SPECIFIC GRAVITY OF WATER AT VARIOUS PLACES AND DATES.

Locality.	Date.	Average temperature.	Average specific gravity.	Maximum specific gravity.	Minimum specific gravity.
Mobile Bay:	1910.	°F.			
Near Buoy Reef	Nov. 17–24	60	1.0166	1.0206	1.0122
2 miles east of Grants Pass	Nov. 29–Dec. 1.	56	1.0206	1.0215	1.0201
Sand Reef	Nov. 23	57	1.0178	1.0191	1.0165
Oyster beds, near Grants Pass	Nov. 24	63	1.0193	...	...
	Dec. 7–9	48	1.0186	1.0210	1.0156
	Dec. 29–Jan. 5.	50	1.0150	1.0200	1.0114
Mississippi Sound, 1 to 2 miles off Mid Signal.	Dec. 5–7	51	1.0235	1.0247	1.0223
	Dec. 12–16	54	1.0209	1.0235	1.0173
	Dec. 20–22	51	1.0213	1.0220	1.0206
	Dec. 29–Jan. 2.	57	1.0191	1.0219	1.0187
	Mar. 20–24	66	1.0198	1.0216	1.0160
	1911.				
Portersville Bay	Jan. 10–11	54	1.0137	1.0167	1.0108
	1910.				
Mississippi Sound, one-half mile west of Coffee Island.	Dec. 9–11	54	1.0228	1.0240	1.0223
	Dec. 17–20	55	1.0219	1.0236	1.0211
	Dec. 22–24	50	1.0205	1.0210	1.0196
	Dec. 27–28	56	1.0205	1.0213	1.0203
	1911.				
	Jan. 3–9	49	1.0207	1.0227	1.0180
	Jan. 10–16	59	1.0180	1.0214	1.0150
	Mar. 14–19	64	1.0205	1.0222	1.0174
	Mar. 25–27	63	1.0198	1.0216	1.0160
	Mar. 29–Apr. 1.	65	1.0197	1.0206	1.0188
	Apr. 6–9	74	1.0170	1.0203	1.0148
Mississippi Bay, 2½ miles south of Grand Bay.	Jan. 17–20	61	1.0178	1.0194	1.0154
	Jan. 24–28	62	1.0175	1.0206	1.0141

It will be observed that the readings in Mississippi Sound, including those on the beds near Grants Pass, cover the period from November 24, 1910, to April 9, 1911, with an intermission from January 17 to March 13. During this period the average specific gravity varied with time and place between 1.0150 and 1.0235 as compared with fresh water as 1.0000 and full ocean water between about 1.0250 and 1.0260. The lowest specific gravity observed during this period was 1.0114 near Pass des Huitres on January 25 and the highest was 1.0247 off Mid Signal early in December.

The maximum specific gravities are probably as high as usually occur in this region, but in times of freshet in neighboring streams the water undoubtedly becomes much fresher than was observed during the survey. In February and March, 1894, when the previous reconnoissance was made, the water at the bottom of the east end of Grants Pass was 1.0028, at the north end of Portersville Bay 1.0036, about 1 mile southeast of Point aux Herbs 1.0063, and in the mouth of Heron Bay 1.0000 or absolutely fresh, in all cases being much lower in salinity than at the corresponding season of 1911.

These low salinities are all of them below that which is desirable for the production of the best oysters, and the lowest, if it long prevailed, would prove fatal. It is apparent, however, that these conditions are but occasional and that normally they do little or no harm. It is probable even that they are beneficial in periodically reducing the saltness of the water below that which can be tolerated by the drill or borer and by that means keeping that destructive enemy from becoming so numerous as to menace the beds.

OYSTER FOOD.

In reports on previous surveys a feature usually has been made of the subject of the quantity of oyster food carried by the waters. These discussions have been confined practically to diatoms, minute microscopic plants, which authors generally have been prone to regard as supplying practically all of the oyster's nutriment. Volumetric studies of the microorganism content of the water begun in connection with the survey of Matagorda Bay [a] in 1905 revealed a quantity so small as to excite the author's suspicion that the living matter was of less relative importance than had been generally supposed.

It appeared possible, however, that the quantity of water filtered by the oyster might be greater than generally supposed and digestion more rapid, and that despite appearances the small quantity of microscopic living organisms in the water and present in the stomach at any one time might be sufficient to furnish material for the growth and general physiological activities of a sluggish animal like the oyster.

[a] Survey of Oyster Bottoms in Matagorda Bay, Tex. By H. F. Moore. Bureau of Fisheries Document No. 610.

To test the matter, apparatus and methods [a] were devised for the volumetric determination of the organisms actually eaten during comparable periods of time. The result of this work, which has been carried on at intervals for several years by the author and Mr. T. E. B. Pope, has shown that while the quantity of water filtered is great, averaging, roughly, about 30 quarts daily for oysters 4½ inches long, the volume of the living food is insufficient to account for the actual growth of the oyster, making no allowance for the requirements of the other vital activities. It appears that finely divided organic débris or detritus, which constitutes the major part of the material ingested, plays a more important rôle in the oyster diet than has been conceded, a view which recently has been advanced by Petersen and Jensen.[b]

In view of these facts and probabilities, and the present impossibility of establishing a standard for the expression of the quantity of food available, the data respecting the food content of the water collected during this survey will not be stated here. A special paper on the entire subject of the food and feeding of oysters will be issued on the completion of the studies.

It may be stated from observation of the oysters and on general grounds that the food supply in Mississippi Sound and minor contiguous waters is ample.

OYSTER ENEMIES.

The survey, since it was carried on during the colder season of the year, was not favorably timed for the study of the enemies of the oyster in this region. The only ones observed were a few drills and mussels, but the drumfish also is known to occur.

Drill, borer, snail, whelk, conch, etc. (*Purpura hæmostoma*).—A comparatively small number of the animals variously known by these several names was found on the natural oyster beds, particularly those in the vicinity of Little Dauphin Island from Pass aux Herons southward. This is the region nearer the mouth of Mobile Bay, and therefore the more accessible to the influx of salt water from the open Gulf.

On some of these beds the drills were found at their work of destruction but in other places their presence at times was to be inferred only by the mortality, especially among the spat and young oysters, which are more susceptible than adult oysters to their attacks.

It can not be stated that these enemies were particularly destructive at the time of the survey, but it is reported that many oysters have been destroyed by them at intervals in the past, and, as might be

[a] Volumetric studies of the food and feeding of oysters. By H. F. Moore. (Proceedings of the Fourth International Fishery Congress, Washington, 1908.) Bulletin Bureau of Fisheries, vol. XXVIII, 1908, p. 1295–1308.

[b] Valuation of the Sea. I.—Animal life of the sea bottom, its food and quantity. By C. G. Joh. Petersen and P. Boysen Jensen. Report of the Danish Biological Station, XX. Copenhagen, 1911.

expected, their inroads appear to have been coincident with periods of prevalence of highly salt water on the beds.

The drill or whelk lays its eggs in red or purple leathery capsules about one-half inch long and attached in clusters to shells, snags, and other firm bodies in the water. The young become destructive to the minute spat immediately on emerging from the egg cases, they grow rapidly, and progress in destructiveness as they increase in size. They destroy the oysters by drilling a small round hole through the shell, using for the purpose a flexible rasp-like organ lying at the end of a protrusible proboscis. After the shell is perforated the proboscis is thrust into the shell and the contents eaten, other drills sometimes partaking of the feast by entering the gaping shell of the dead or dying oyster. Most of the oysters destroyed are under 2 inches long.

Mussels.—The common black sea mussel is a passive enemy of oysters through its tendency to attach to them and under favorable conditions to grow so rapidly and in such numbers as to cover them completely and stifle them. Also, as its food is the same as that of the oyster, its abundance reduces the supply and in that way deprives the oyster of the nutriment required to make it fat and marketable. Even when neither of these effects are important, mussels injure the fishery, owing to the tenacity with which they are anchored to the oyster, this increasing the labor of culling and making the oyster so unsightly from the adhering fibers of the byssus as to considerably reduce its market value if sold as shell stock. The conditions which make for the abundance of the mussel are not thoroughly understood, but on the Gulf coast it appears to be controlled largely by the relative freshness of the water, the mussels generally flourishing where the salinity is low for prolonged periods. Comparatively few were found in the region surveyed and it is probable that they never or rarely become troublesome on account of the high salinity frequently occurring.

Drumfish (*Pogonias cromis*).—This, the "black drum," was not observed during the survey, but it is a destructive enemy of the oyster in other parts of the Gulf coast and is reported to destroy oysters on the beds of Alabama. It is migatory, making sudden forays and leaving, with destruction in its wake, often before its presence has been noticed. It destroys the oysters by crushing them between the stout grinding teeth or bones with which its mouth is furnished, and it is peculiarly destructive to the better grade of planted beds, on which the oysters have been culled and separated to permit them to grow and improve in shape and quality. It is especially likely to attack the culled oysters within a few weeks of the time when they are planted, but they are not immune at any time. In Louisiana the drumfish is so destructive in places that the oystermen find it necessary to exclude them by surrounding their bedding grounds with wire fences.

Oysters in the natural beds, especially when they are much clustered and of the sharp-edged raccoon type, are rarely injured seriously, as the sharp edges of the shells, presented in all directions, lacerate the lips and mouths of the fish and deter them from extensive destruction. Occasionally the small oysters culled off by the oystermen are damaged.

The drumfish occurs in waters of all degrees of salinity, from fresh or practically fresh to full oceanic density.

SPAWNING.

The survey was conducted at the season when the reproductive functions of oysters are in abeyance, and therefore no definite statement of the spawning season in Alabama can be made. Various investigations carried on by the Bureau at the western end of Mississippi Sound, where the general conditions affecting spawning are essentially the same as at the eastern end, make it possible to indicate with some precision the period during which the spawn is likely to be emitted.

It is probable that the eggs may ripen even in the winter, during sustained warm periods, but it is doubtful if in these cases, even though the eggs be fertilized, development ever proceeds far enough to secure a set of spat. The normal spawning probably occurs from April to October, as it does in similar waters in Louisiana, and clean shells or other cultch planted during those months should receive a good set of spat. The young oysters are free-swimming organisms during a short period of their early life, and as they are produced in untold myriads on the crowded natural beds and carried considerable distances by the currents, the water over a large part of the sound must be teeming with the fry during the favorable part of the year. Most of these embryo oysters perish through falling on unsuitable bottom at the beginning of the shell formation, when they are still barely visible to the unaided eye and may be stifled by an exceedingly thin deposit of mud or slime. Those fortunate enough to alight on shells or other oysters, and similar firm supports, survive in large numbers, as is witnessed by the crowded condition of the beds, but over the vastly greater proportion of the bottom there is nothing to afford a haven. The only fundamental difference between an oyster bed and the surrounding barren bottom is that the former presents places for the attachment of the spat and the latter does not.

Many free-swimming oyster fry die as the result of sudden drops in the temperature, though this is not common on the Gulf coast; and many are killed by heavy rainfalls. The latter also tend to retard or suspend spawning through lowering the salinity of the water, and it frequently happens that heavy freshets defer spawning until summer. As freshets usually leave the shells and other cultch in excellent con-

dition so far as cleanliness is concerned, probably through the destruction of slime-producing organisms, it frequently happens that a late spawning season produces an enormous set.

OYSTER CULTURE.

In the United States oyster culture is carried on by two methods, the planting of seed or young oysters and the deposit of shells and similar materials on the bottom for the purpose of securing the fixation of spat. The first of these is that which is generally, if not exclusively, employed in Mobile County, Ala., and it is probable that in the immediate future it will continue to be the dominant practice in that region.

The large number of small oysters in certain of the natural beds, as described in the foregoing pages, renders it advisable that some of them be removed to permit the proper growth and fattening of the remainder. These superfluous young can be utilized to best advantage if planted on suitable barren or depleted bottom. For ordinary cannery purposes merely the roughest culling of this seed is required, but if it be desired to produce oysters for consumption on the shell or for shipping raw shucked, the large clusters should be broken up. By this means only can they be grown to goodly shape, for if crowded they must accommodate themselves to the space available and will develop into irregular and inferior stock. It is usually not necessary to break the clusters into single oysters, and it is often inadvisable to do so, especially in localities in which the drumfish is likely to occur in numbers. As has already been explained this fish is particularly destructive to culled oysters. The method of planting shells, etc., to promote the attachment of young oysters is highly productive in many localities on the coast of the United States, and in the case of a large development of the oyster industry in Alabama is that in which chief reliance must be placed. The system first described saves oysters which have already set and gives them an opportunity to survive and improve, but shell or cultch planting increases the set by preventing the loss of the fry falling on muddy and other unsuitable bottoms.

It is not necessary to give here an account of the methods of oyster culture, as the subject is discussed in a special pamphlet[a] which may be obtained, on request, of the Bureau of Fisheries.

Within the limits of the survey oyster culture is at present carried on principally along the north shore of Mississippi Sound, although it is understood that there are a few small planted beds in Dauphin Island Bay and vicinity. The north shore beds are located in Heron, Portersville, Fowl River, and Isle aux Dames Bays. No oysters

[a] Oysters and methods of oyster culture. By H. F. Moore. Bureau of Fisheries Document No. 349. Extract from Manual of Fish Culture, p. 263–340, pl. I–XVIII, 1900.

from Heron Bay were examined, but some of excellent quality were seen in the last three localities mentioned. The State bed in Portersville Bay was planted too dense and the quality of its product was correspondingly inferior.

The private beds at the time of the survey were apparently all or practically all held under rights attaching to the ownership of the adjacent shores, this until recently being the only manner in which oyster culture could be legally conducted.

It is now possible, however, to procure from the State the lease of barren bottoms beyond riparian control, and this should result in a material increase in the extent of oyster planting and in the prosperity and development of the entire oyster industry of the State.

As is shown in the chart and explained in the section relating to barren bottoms, there are considerable areas of suitable bottom remote from the shores, and in some cases lying well out in the sound in a depth of water permitting the use of methods warranting operations on a large scale. The possible drawback to some of these offshore locations is the occasional high salinity of the water, which may permit the drill to flourish at times and prove destructive, but on the other hand it might operate to prevent an undue development of young oysters on seed too large for the drill to injure. On the other hand, they are less subject than the inshore waters to damage by freshets. For operations on a smaller scale, in which ease of guarding against theft and facility in tonging are considerations, the shallower waters off Portersville and Grand Bay offer advantages.

RÉSUMÉ, CONCLUSIONS, AND RECOMMENDATIONS.

The following epitomizes the facts developed by the survey, the deductions made therefrom, and recommendations based on them and a consideration of the general conditions obtaining in Mobile County:

1. The survey embraced Mississippi Sound in Alabama and the adjacent part of Mobile Bay, including both the natural oyster beds and the barren bottoms.

2. It was found that the natural oyster beds within this region embraced 4,008 acres, nearly all being near the junction of Mobile Bay and Mississippi Sound. Of this area practically one-half bore oysters in sufficient quantity to warrant tonging and, to a less extent, dredging. On the remainder the oysters are too scattered to be commercially available; but between 500 and 1,000 acres are likely to become productive eventually should there be several years of heavy strike. Probably 1,000 acres are not likely to become productive under natural conditions for many years.

3. It is conservatively estimated that in January, 1911, these beds contained approximately 600,000 bushels of oysters over 3 inches long

and about 460,000 bushels of smaller ones. As the oysters are measured in the fishery, these estimates would be increased to about 800,000 and 600,000 bushels, respectively. As an active fishery had been conducted for some time prior to January, the content of the beds at the beginning of the season was considerably greater.

4. Although the quantity of small oysters on these beds is less than of oysters of marketable size, they are numerically in excess. On the areas indicated as bearing a dense growth there are two small oysters and on the scattering growth four small oysters to each one over 3 inches long. As an average of one year would be sufficient to promote most of the young to the marketable class, it is apparent that in the absence of disaster due to freshets or oyster enemies it would be safe to take from these beds at least about 600,000 bushels, as measured by oystermen, without fear of depletion. This is over twice the quantity taken in Mobile County during 1911. Some of the beds do not at present produce oysters of good quality; but these would doubtless improve under a judicious removal of part of their contents either for canning or, preferably, for transplanting either on depleted natural beds or on private grounds.

5. While the increased take from the natural beds indicated in the preceding paragraph as safely allowable would permit a valuable expansion in the oyster industry of the State, it without doubt will not suffice for the supply of the ultimate demand, and eventually it will be necessary to greatly increase the area of the oyster-producing bottom. The demand will have two sources—the canneries and the shell-stock and raw-shucking trade. While the former can be satisfied by the class of oyster produced by the natural reefs, the latter to a large extent demands a better grade. The demand, therefore, will be for not only an increase in quantity, but an improvement in quality.

6. The conditions stated at the close of the preceding paragraph can not be fully satisfied excepting by a resort to oyster culture under private ownership, with its consequent demand of personal interest and attention. Until recently the laws of Alabama have restricted the rights to engage in oyster culture to riparian owners and their lessees, but the present law permits the lease of any barren bottoms belonging to the State. According to the survey, these are in Mississippi Sound and its contiguous bodies within the limits of Alabama, approximately 25,000 acres of barren bottom suitable for oyster planting or which can be made suitable at small expense. Part of this is in open waters with considerable depth and part in sheltered shallow places, thus affording advantages for operation on both large and small scales.

7. In common with other places on the Gulf coast, these waters offer to the oyster planter a field less exposed to the storms and

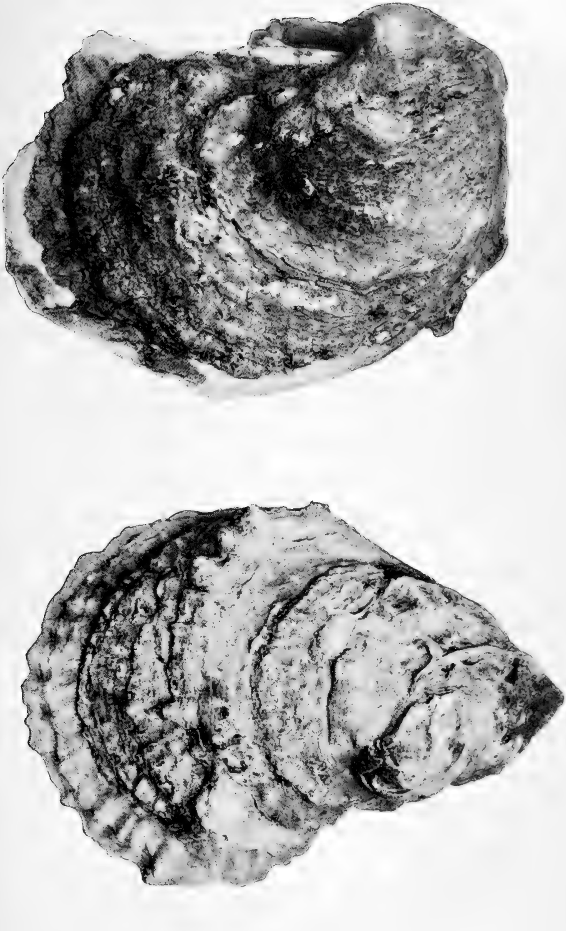
rigors of winter and therefore less subject to interruption than in the North, but on the other hand with a shorter season owing to the late fall and early spring. They have the further advantage that a yearly set of spat is assured and the growth much more rapid than in other waters. The enemies to contend with are no worse than in many places in the North, but in the inshore waters there is possibly more frequent damage from freshets.

8. The sparse population on the shores near the oyster bottoms renders the oysters little subject to injurious pollution from drainage and sewage discharges. This consideration is an important asset at a time when the spread of infection through oysters is a matter of such widespread public concern, and for business reasons, if for no others, the cleanliness of the beds and the treatment of the oysters should be jealously safeguarded. For this reason the process of floating, freshening, or "fattening" the oysters should be rigorously supervised and absolutely prohibited if streams or other waters receiving a sewage discharge or similar contamination are utilized for the purpose. Not only the State oyster commission and boards of health but the oystermen themselves should see that nothing is done to jeopardize public health. Aside from the moral aspect of the matter the future of the oyster industry depends largely on a maintenance of the reputation of its product for cleanliness and wholesomeness.

9. One of the most valuable and certainly the most enduringly valuable results of the survey is the establishment of permanently marked and accurately determined triangulation points by the United States Coast and Geodetic Survey, supplemented by a few established by the Bureau of Fisheries. In all future surveys of leased bottoms, these should be utilized and the corners of the leaseholds determined by reference to them. A strict and consistent compliance with this recommendation will prevent disputes and litigation should oyster planting become as important as it has in other places and it will insure accuracy in the surveys, guaranteeing an honest return to the State from the rental of its barren bottoms.

OYSTER CLUSTER FROM GRANTS PASS.

SINGLE OYSTER FROM GRANTS PASS.



SINGLE OYSTERS FROM PASS AUX HERONS.

OYSTER CLUSTER FROM STATE-PLANTED BED IN PORTERSVILLE BAY.

SINGLE OYSTER FROM PRIVATE-PLANTED BED IN PORTERSVILLE BAY.

DESCRIPTION OF CHART.

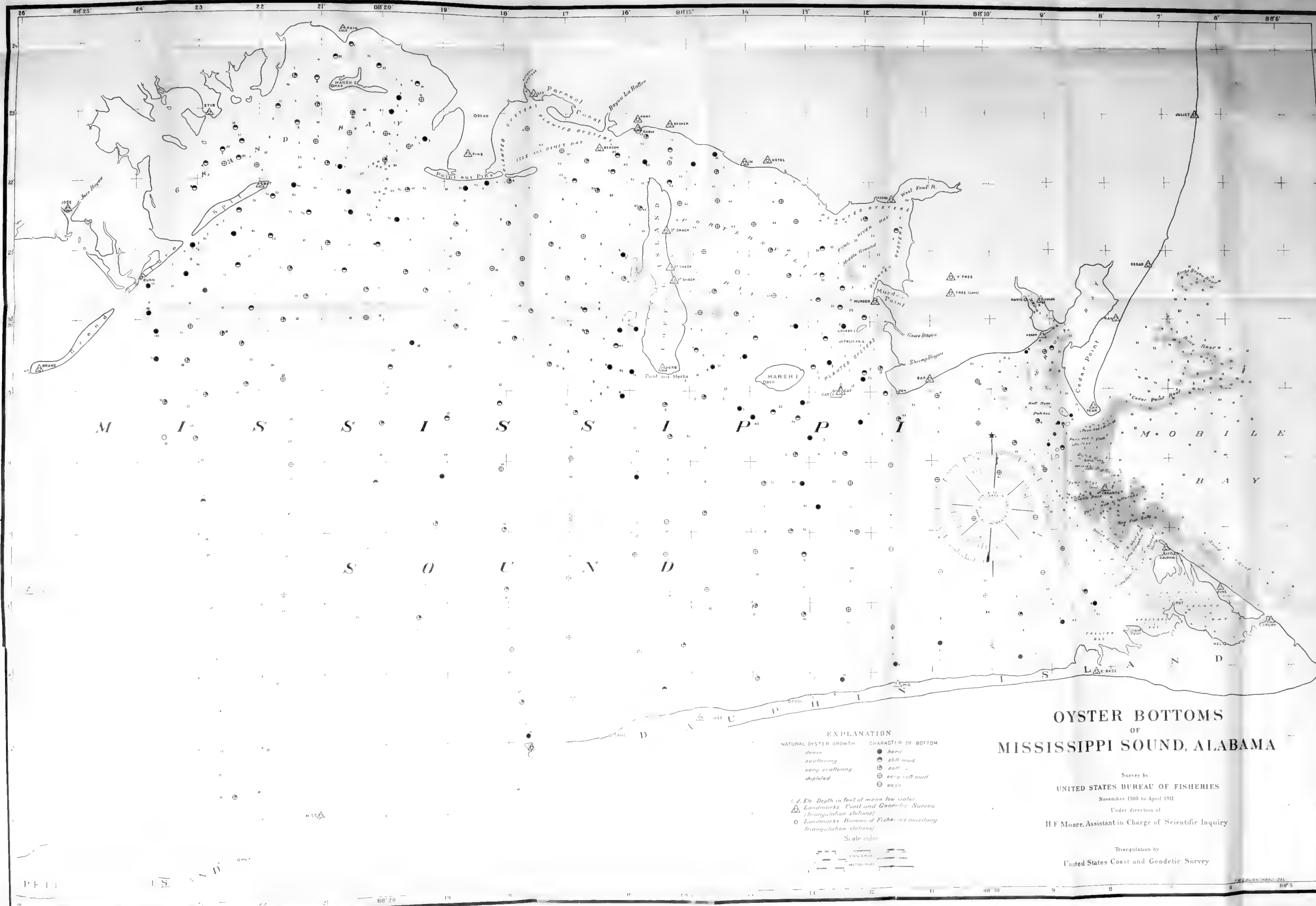
The chart shows the character and location of the natural oyster beds and the barren bottom. The oyster beds are included within solid orange lines and the density of the growth of oysters over 3 inches long is indicated by the relative intensity of the shading. In this classification the small oysters are disregarded and it therefore may happen that a dense growth of oysters under 3 inches in length may occur in an area shown as scattering.

Barren bottom is unshaded, but its character as to consistency is indicated by circular symbols. Hard bottom is shown by solid black circles, ooze by circles with a horizontal diameter, and intermediate consistencies by intermediate symbols. The more open the circle, the softer is the bottom which it represents. Not all stations at which the bottom was tested are shown, the purpose being to indicate the general character and the transitions from one to the other.

Depths are expressed in feet and refer to mean low water.

The triangulation stations of the United States Coast and Geodetic Survey, which were determined with great accuracy and are permanently marked with concrete monuments, are shown by triangles with an included circle.

The subsidiary triangulation stations of the Bureau of Fisheries, less accurately determined and marked by concrete monuments with an iron pipe in the center, are shown by means of circles. The names of the stations are those used by the hydrographic party and are usually abbreviations of the full name used by the Coast and Geodetic Survey.



OYSTER BOTTOMS
OF
MISSISSIPPI SOUND, ALABAMA
Survey by
UNITED STATES BUREAU OF FISHERIES
November 1910 to April 1911
Under direction of
H. F. Moore, Assistant in Charge of Scientific Inquiry
Triangulation by
United States Coast and Geodetic Survey
EXPLANATION
NATURAL OYSTER GROWTH
dense
scattering
very scattering
depleted
CHARACTER OF BOTTOM
hard
stiff mud
soft
very soft mud
oozo
1, 2, Etc. Depth in feet at mean low water
Landmarks Coast and Geodetic Survey (triangulation stations)
Landmarks Bureau of Fisheries (auxiliary triangulation stations)
MISSISSIPPI
SOUND
MOBILE
BAY
DAUPHIN ISLAND
GRAND BAY
SPIT
Point aux Pins
Isle aux Dames Bay
Bayou La Batre
Portersville Bay
Fowl River Bay
West Fowl R.
Middle Ground
Murder Point
Goose Bayou
Shrimp Bayou
Marsh I.
Point aux Herbs
Cedar Point
Cedar Point Reef
Heron Bay
Planted Oysters
Parsonal Coast

CONDITION AND EXTENT OF THE NATURAL OYSTER BEDS AND BARREN BOTTOMS OF MISSISSIPPI EAST OF BILOXI

By H. F. Moore

Assistant in Charge of Scientific Inquiry

Bureau of Fisheries Document No. 774

CONTENTS.

CONDITION AND EXTENT OF THE NATURAL OYSTER BEDS AND BARREN BOTTOMS OF MISSISSIPPI EAST OF BILOXI.

By H. F. Moore,
Assistant in Charge of Scientific Inquiry.

INTRODUCTION.

This investigation was made at the request of Hon. E. J. Noel, Governor of Mississippi, in connection with a similar survey in Alabama which already had been provided for. Had not the latter been in progress it is probable that work would have been conducted near the western end of Mississippi Sound, where the natural beds are more extensive and productive, but the economy in time effected by the contiguity of the two areas to be surveyed was a controlling factor in deciding the locus of the Mississippi investigations.

There are extensive oyster interests within the area embraced by the survey, but the beds upon which they depend are principally near the western limits of the State. Formerly the largest quantity and the best quality of the oysters used in the canning and shucking houses of Mississippi came from Louisiana, but legislation in that State has placed impediments on the export of oysters to be canned or shucked in other States, with the result that the Mississippi industry has been more or less seriously handicapped for lack of proper raw material. A limited quantity of oysters is brought from Alabama for packing, principally at Biloxi.

The triangulation on which the survey was based was furnished for the purpose by the United States Coast and Geodetic Survey, and is therefore accurate. All of the points established, excepting buildings and other structures of like character, are marked by substantial concrete monuments. Should Mississippi establish a system of leasing her barren bottoms for purposes of oyster culture these stations will furnish an invaluable basis for the survey of the leaseholds. With the reference points which they furnish it will be possible to measure the areas accurately and to locate the corners in a manner which will make impossible disputes between contiguous holders and between the lessees and the State. In all States in which oyster culture has been long established the importance of being able to refer the water surveys to permanent and accurately determined points on shore is recognized as necessary to prevent litigation, fraud, and loss to the State, and in many cases the States have been impelled to establish such marks at much expense to themselves. The survey of the actual oyster beds and the barren bottoms was conducted by the Bureau of Fisheries in February and March, 1911. The work consisted of the determination

of the location and extent of the oyster beds by means of biological and hydrographic examinations and investigation of the character of the barren bottoms in respect to their suitability for purposes of oyster culture. No previous investigation of this character has been made in the region covered by the survey, and there is therefore nothing on which to base comparisons with past conditions, and no way in which to determine to what extent changes in the beds have been effected by the oyster fishery or variations in the physical characteristics of the waters and the adjacent land.

METHODS OF THE SURVEY.

The methods employed were those pursued in former surveys of like character, and are explained in detail in a description of the beds of the James River,[a] from which some of the following is repeated:

A "boat sheet" was prepared, on which were accurately platted the positions, as determined by triangulation, of lighthouses, buildings, tripods, etc., used as signals. These data were furnished by the United States Coast and Geodetic Survey.

The oyster beds were discovered by soundings with a lead line, but principally by means of a length of chain dragged over the bottom at the end of a copper wire running from the sounding boat. The wire was wound on a reel and its unwound length was adjusted to the depth of water and the speed of the launch, so that the chain was always on the bottom. Whenever the chain touched a shell or an oyster the shock or vibration was transmitted up the wire to the hand of a man whose sole duty it was to give heed to such signals and report them to the recorder.

The launches from which the soundings were made were run at a speed of between 3 and 4 miles per hour. At intervals of three minutes—in some cases two minutes—the position of the boat was determined by two simultaneous sextant observations of the angles between a set of three signals, the middle one of which was common to the two angles, the position being immediately platted on the boat sheet. At regular intervals of 15 seconds, as measured by a clock under the observation of the recorder, the leadsman made a sounding and reported to the recorder the depth of the water and the character of the bottom, immediately after which the man at the wire reported the character of the chain indications since the last sounding—that is, whether they showed barren bottom or dense, scattering, or very scattering growths of oysters.

With the boat running at 3 miles per hour the soundings were between 60 and 70 feet apart, and, as the speed of the boat was uniform, the location of each was determinable within a yard or two by dividing the platted distance between the positions determined by the sextant by the number of soundings. The chain, of course, gave a continuous

[a] Moore, H. F.: Condition and extent of the oyster beds of James River, Va. Bureau of Fisheries Document No. 729.

indication of the character of the bottom, but the record was made at the regular 15-second intervals observed in sounding.

The chain, while indicating the absence or the relative abundance of objects on the bottom, gives no information as to whether they are shells or oysters, nor, if the latter, their size and condition. To obtain these data it was necessary to supplement the observations already described by others more definite in respect to the desired particulars. Whenever, in the opinion of the officer in charge of the sounding boat, such information was required, a numbered buoy was dropped, the time and number being entered in the sounding book. Another launch, following the sounding boat, anchored alongside the buoy, and a quantity of the oysters and shells were tonged up, separated by sizes, and counted.

This boat at each station made a known number of "grabs" with the oyster tongs, exercising care to clean the bottom of oysters as thoroughly as possible at each grab. In a given depth of water and using the same boat and tongs, an oysterman will cover practically the same area of the bottom at each grab, but, other factors remaining the same, the area of the grab will decrease with an increase in the depth.

Careful measurements were made and tabulated showing the area per grab covered by the tonger employed on the work at each foot of depth of water and for each pair of tongs and boat used. With these data, and knowing the number of "grabs," the number of oysters of each size per square yard of bottom was readily obtainable by simple calculation. The following example will illustrate the data obtained and the form of the record:

DEPARTMENT OF COMMERCE AND LABOR.

BUREAU OF FISHERIES.

Field record of examinations of oyster beds.

General locality, *Mississppi Sound.*
Local name of oyster ground, *Scranton Reef.*
Date, *February 1, 1911.* Time, 2.00 p. m.
Angle, *H 101.* Buoy No. *6.*
Depth, *4.3.* Bottom, *Soft, over 7½″.*
Condition of water, *Thick.*
Density, *1.016.* Temperature, *19.*
Current, Stage of tide, *Flood.*
No. grabs made, *8.* Tongs, *10 feet.*
Total area covered, *2.36* square yards.

No. oysters taken $\left\{\begin{array}{ll}\text{—1 in., } \mathit{20}. & \text{1 in.–3 in., } \mathit{101}. \\ \text{3 in.–4 in., } \mathit{11}. & \text{4 in., } \mathit{0}.\end{array}\right.$

Quantity shells, *0.* *8 dead.*

Result $\left\{\begin{array}{l}\text{Spat per square yard, } \mathit{8.3}. \\ \text{Culls per square yard, } \mathit{42.2}. \\ \text{Counts per square yard, } \mathit{4.6}.\end{array}\right.$

This furnishes an exact statement of the condition of the bed at the spot, which can be platted on the chart with error in position of not more than a few yards. From the data obtained a close estimate may be formed of the number of bushels of oysters and shells per acre in the vicinity of the examination, and, by multiplying the observations, for the bed as a whole. In the course of the survey 472 observations were made at various places, principally on the natural rocks, but some on the barren bottoms also.

In estimating the productiveness of the bottoms it appeared desirable to use the method employed in Delaware Bay [a] rather than that followed in the James River survey.

Where tongs are used exclusively a bed with a given quantity of oysters lying in shoal water is more valuable commercially than one with the same quantity of oysters in deeper water, owing to the fact that the labor of the tonger is more efficient on the former. As has been pointed out, the area covered by a "grab" decreases with the depth, other factors being the same; and, moreover, the deeper the water the greater is the labor involved in making the grab and the smaller is the number of grabs which can be made in a given time. Where, however, the depth is practically uniform and shoal, as in the region treated in this report, it is unnecessarily refined and laborious to make such allowance for depth, and it is nearly as accurate and satisfactory to rate the bottoms in accordance with an arbitrary standard.

In this report the classification of the relative productiveness of the various beds and parts of beds, as exhibited on the chart and discussed in the text, is as follows:

Dense growth	Bearing over 150 bushels per acre.
Scattering growth	Bearing between 75 and 150 bushels per acre.
Very scattering growth	Bearing between 25 and 75 bushels per acre.
Depleted bottom	Bearing less than 25 bushels per acre.

This classification refers solely to oysters of a size assumed to be large enough for the market, in this case to those 3 inches or more in length, although the cull law of Mississippi permits oysters 2½ inches long to be taken from the public beds. As the classification takes no account of the smaller oysters, certain areas bearing a heavy growth of young may be described and shown on the chart as depleted, owing to the paucity of mature oysters. A case of this character is the depleted part of West Pascagoula, where there are but 3 bushels of market oysters per acre and 279 bushels of small ones. While the charts can not indicate this, the descriptions of the beds show it in all cases. The charts show in general terms the character of the beds in respect to the product available for market, so far as mere size

[a] Condition and extent of the natural oyster beds of Delaware. By H. F. Moore, assistant, United States Bureau of Fisheries. Bureau of Fisheries Document No. 745, 1911.

of the oysters is concerned, at the time of the survey. If the oysters were of ordinarily good condition and shape, which unfortunately in most cases they were not, the areas indicated as bearing dense and scattering growth would yield a product sufficient to make tonging remunerative under the economic conditions existing. Where the market oysters are rated as very scattering, the growth is insufficient to support a fishery at the low price which the product would yield. The depleted bottom is that on which the product of market oysters, at the time of the survey, was very small, and is not necessarily formerly productive bottom now denuded, as might be supposed from a strict definition of the descriptive term employed. On the contrary, it may be formerly barren bottom now coming into production.

The barren bottom, which is that totally devoid of oysters, and in most cases of shells, vastly exceeds the oyster bottom in extent. Its interest in connection with the survey lies in its relative availability for oyster culture; that is, whether or not its general character is such as to enable it to become productive if proper measures to that end be taken. The most important consideration is, usually, the character and degree of stability of its constituent materials. If the bottom be too soft the shells and oysters deposited thereon will soon become engulfed.

In previous surveys the method ordinarily used by oystermen has been employed, the consistency of the bottom being determined by probing with a pole. By noting the resistance which the bottom imposes to the penetration of the probe, the observer forms an opinion of its relative hardness and of its suitability, in that respect, for oyster culture. In many cases different observers will not agree as to the proper term by which to describe the bottom so tested, and it is therefore difficult to convey to another the meaning desired. To overcome this difficulty an instrument[a] has been devised which gives these data mechanically, by measuring the number of inches the bottom is penetrated by a plunger of a constant weight and size falling through a uniform distance. The instrument is used from an anchored boat, from 6 to 10 tests being made at each station. Any readings which are markedly higher or lower than the others are discarded on the assumption that the plunger has fallen into a crab hole or other depression, or that it has encountered a shell or similar accidental obstruction. The average of the remaining depths of penetration, as indicated on the scale of inches inscribed on the rod, is regarded as the measure of the consistency of the bottom.

[a] Illustrated and described in "Condition and extent of the natural oyster beds and barren bottoms of Mississippi Sound, Alabama." By H. F. Moore, Bureau of Fisheries Document No. 769.

The following designations used to indicate the different degrees of hardness, as shown by the instrument, are arbitrary, although based on the terms used by the oyster growers:

Hard	Penetration less than 4 inches.
Stiff	Penetration between 4 and 8 inches.
Soft	Penetration between 8 and 13 inches.
Very soft	Penetration between 13 and 18 inches.
Ooze	Penetration over 18 inches.

These various types of bottom are shown on the chart by means of circles, the relative area of black included within them indicating the relative degree of hardness, as follows: Hard, a black circle; stiff, a black semicircle; soft, a black quadrant; very soft, two crossing diameters; ooze, one diameter.

The bottoms classed as hard and stiff, those in which the plunger will not penetrate more than 8 inches, are suitable for planting without preparation, provided they are not composed of shifting sand. As sand invariably gives a reading of less than 4 inches, and is therefore rated as "hard," it follows that all "stiff" bottom shown on the chart by a black semicircle can be accepted as safe for planting. Part of the hard bottom is composed of mud and part of sand. The former may be accepted without hesitation, but the latter should be examined with respect to its liability to shift. Soft bottom should be planted with care, and toward its upper or less consistent limits may require some preliminary hardening with shells or sand. Very soft bottom and ooze should not be considered, as oysters planted there will sink, and if not killed, as is probable, will be ill shaped and inferior in every respect. The ratings on which the classification is based have been checked by observation on bottoms actually used for oyster culture in Chesapeake Bay.

The instrument employed has been thoroughly tested and is reliable for the purposes of oyster surveys, but there may be errors in cases where hard bottom is overlaid by several inches of soft mud and ooze. Such bottoms are always readily detected by probing with a pole.

During the course of the survey 10,472 soundings were made and 1,826 angles for the position of the boat were taken on lines aggregating a length of 211 miles, over which the chain was dragged continuously. In addition to the soundings and the use of the chain on the beds, oysters were tonged, examined, and counted, and other biological observations were made at 129 places. The barren bottoms were tested with the instrument previously described at 343 places, at each of which from 6 to 10 observations were made. The data of the survey therefore includes upward of 10,000 soundings, 211 miles of continuous chain readings, and 472 special examinations of the bottom and its contents. The whole area covered was about 75,000 acres, of which 1,708 acres were oyster-bearing bottom.

DESCRIPTION OF NATURAL BEDS.

SCRANTON REEF.

Scranton Reef lies in the shallow water west of the mouth of Pascagoula River. It is roughly rectangular in shape, stretching for upward of 1¼ miles in a southwesterly direction from the depleted bottom close to shore to a depth of 3 or 4 feet at its outer edge. Its former natural limits apparently have been greatly extended within a recent period, partly by the ordinary operations of oystering, partly through the agency of gales which have distributed oysters and shells over the surrounding mud and sand and, principally, through planting operations, reported to have been conducted by the State on the originally barren bottom contiguous to the offshore margin of the natural bed.

The original reef, and practically the only part of the present bed which has reef-like characteristics, is a narrow strip of raccoon oysters having a length of about 1¼ miles in an approximately east and west direction, and an average width of about 200 yards. The later natural and artificial accretions to the bed lie north and south of this ridge.

The bed constitutes the largest continuous area of oyster growth in that part of Mississippi covered by the survey, but the oysters at the time of examination were small, rough, and inferior, and there is every reason to believe that that has been their condition for some years. During the time of the survey practically no oysters were taken from the bed.

The area, condition of oyster growth, and estimated content of this bed are shown in the following table:

OYSTER GROWTH ON SCRANTON REEF.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	44	740	278	32,560	12,232	44,792
Scattering	105	447	117	46,935	12,285	59,220
Very scattering	402	206	47	82,812	18,894	101,706
Depleted	262	27	9	7,074	2,358	9,432
Total	813			169,381	45,769	215,150

The dense growth lies in the planted area outside the original reef as an arcuate strip about one-half mile long and 250 yards wide. The depth of water over this is about a foot less than on the adjacent bottom bearing a more scattering growth, and varies from about 2½ feet at the northern to 4 feet at the southern end of the strip. It is

probable that included in this area may be some natural oyster beds or patches, although they may have been reduced to mere areas of hard bottom prior to the time at which they are alleged to have been planted by the State. The shoaling of the water over the strip indicates either this or an extraordinary production after planting. There are very few oysters over 4 inches long on this area and for every oyster 3 inches long or more there are 6 or more under that length, and all are poor in every respect.

South of this strip and continuous with it in a depth of 4 to 5 feet is an area of scattering oysters, but the principal growth of that character lies on the old ridge previously described. On the crest of the ridge the depth is generally 1 foot or less, but the scattering growth passes to a depth of about 2½ feet at the western end in a channel running to one of the bayous. In this area there is hardly an oyster reaching a length of 4 inches and there are nearly nine times as many under 3 inches as over that. This does not mean that there is an enormous production of young, though that is also true, but that the conditions are such as to prevent oysters growing to a large size even though they may attain a considerable age. In most places examined they were densely clustered, though in one or two spots small single oysters are found in considerable numbers. There were some drills and in one or two places considerable algæ or "moss." The very scattering growth which constitutes about one-half of the entire bed lies in the two areas practically surrounding the denser growth. The smaller of the two is inside of the ridge in water not exceeding 2 feet deep. The larger lies outside of the ridge and on all sides of the area of dense growth previously described. In oysters of marketable size, that is those measuring 3 inches or more in length, the productiveness of the two is about equal, but small oysters are in greater abundance in the outer or planted area, especially in that part of it lying west of the dense growth.

The depleted bottom is confined to the northern and eastern borders of the bed. Over the former it is characterized by the clusters of small oysters sparsely scattered, and apparently owes its existence to a set on shells carried from the more productive bottoms by storms.

DETAILS OF EXAMINATION OF SCRANTON REEF.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	*Feet.*						*Bush.*	*Bush.*	*Bush.*
845	Feb. 1	4.0	Dense	18.5	87.0	10.8	0	738.5	172.8	911.3
886	Feb. 2	3.5	...do	16.0	90.0	24.0	0	742	384	1,126
852	Feb. 1	2.1	Scattering	5.5	97.5	7.5	0	721	120	841
860	...do	2.0	...do	3.0	141.0	5.0	0	1,008	80	1,088
868	Feb. 2	2.1	...do	.3	12.9	6.8	0	92.4	108.8	201.2
883	...do	3.3	...do	6.0	41.3	12.7	0	333.1	203.2	536.3
884	...do	1.5	...do	7.7	55.8	5.0	0	444.5	80	524.5
887	...do	4.0	...do	2.5	9.5	7.0	0	84	112	196
843	Feb. 1	4.3	Very scattering	8.3	42.2	4.6	0	353.5	73.6	427.1
844	...do	4.0	...do	21.1	23.3	4.4	0	310.8	70.4	381.2
846	...do	3.8	...do	.0	37.8	2.2	0	264.6	35.2	299.8
851	...do	2.8	...do	.0	.9	.6	0	6.3	9.6	15.9
853	...do	3.1	...do	.0	16.6	1.6	0	116.2	25.6	141.8
858	...do	3.1	...do	.0	4.7	1.9	0	32.9	30.4	63.3
859	...do	3.2	...do	.0	47.5	2.9	0	332.5	46.4	378.9
869	Feb. 2	2.0	...do	.5	75.0	2.0	0	528.5	32	560.5
870	...do	2.0	...do	2.9	24.8	4.2	0	193.9	67.2	261.1
874	...do	4.0	...do	10.7	4.4	1.9	0	105.7	30.4	136.1
878	...do	4.0	...do	20.5	13.5	2.0	0	238	32	270
879	...do	3.5	...do	4.1	2.7	2.3	0	47.6	36.8	84.4
880	...do	4.0	...do	5.5	1.0	1.5	0	45.5	24	69.5
881	...do	2.0	...do	6.8	56.8	1.9	8	445.2	30.4	475.6
882	...do	4.0	...do	6.5	21.0	4.5	0	192.5	72	264.5
885	...do	2.8	...do	2.5	5.4	4.2	0	55.3	67.2	122.5
888	...do	2.3	...do	7.8	86.6	2.2	0	660.8	35.2	696
889	...do	1.5	...do	...	...	...	...	...	...	...
890	...do	2.6	...do	1.9	15.9	1.1	5	124.6	17.6	142.2
894	...do	3.0	...do	.4	20.4	7.2	0	145.6	115.2	260.8
895	...do	2.0	...do	...	...	...	...	...	...	...
896	...do	1.0	...do	.3	4.4	3.3	0	32.9	52.8	85.7
897	...do	1.3	...do	...	...	...	...	...	...	...
898	...do	3.0	...do	.0	14.2	4.6	0	99.4	73.6	173
806	Jan. 31	4.0	Depleted	.0	1.1	.0	0	7.7	.0	7.7
807	...do	4.3	...do	.0	.0	.0	0	.0	.0	.0
854	Feb. 1	3.5	...do	1.3	7.7	.7	0	63	11.2	74.2
855	...do	3.0	...do	.0	.6	.3	0	4.2	4.8	9
856	...do	3.1	...do	.0	10.3	.9	0	72.1	14.4	86.5
857	...do	2.2	...do	.0	.5	.8	0	3.5	12.8	16.3
865	Feb. 2	2.0	...do	...	...	...	...	...	...	...
866	...do	2.5	...do	...	...	...	...	...	...	...
867	...do	2.0	...do	3.2	4.8	1.0	1	56	16	72
871	...do	3.1	...do	.8	.0	.4	0	5.6	6.4	12
872	...do	3.8	...do	.0	.5	1.0	1	3.5	16	19.5
875	...do	4.3	...do	3.3	4.4	.4	0	53.9	6.4	60.3
891	...do	3.0	...do	.0	3.4	.9	0	23.8	14.4	38.2
893	...do	3.0	...do	.0	4.7	.0	0	32.9	.0	32.9
899	...do	1.8	...do	...	...	...	...	...	...	...

PATCHES NEAR SCRANTON REEF.

At a distance of a few hundred yards from the western and southwestern margin of Scranton Reef are several small patches of what appears to be a natural growth of oysters. None of these are of material importance and but one examination was made on each, although one or two lines of soundings were carried over them. The areas and productivity of these patches are shown in the table following.

OYSTER GROWTH ON PATCHES NEAR SCRANTON REEF.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Scattering	10	207	77	2,070	770	2,840
Very scattering	10	270	36	2,700	360	3,060
Depleted	8	4	3	32	24	56
Total	28			4,802	1,154	5,956

The area of scattering growth, which covers about 10 acres, lies northwest of Scranton Reef proper in the shallow channel running into West Pascagoula River. The larger of the patches of scattering growth and the depleted bottom lie on the eastern edge of the sand spit between Scranton and West Pascagoula Reefs.

The following data are derived from the examination of these patches:

DETAILS OF EXAMINATION OF PATCHES NEAR SCRANTON REEF.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	*Feet.*						*Bush.*	*Bush.*	*Bush.*
847	Feb. 1	4.0	Scattering	2.2	27.4	4.8	0	207.2	76.8	284.0
809	Jan. 31	4.0	Very scattering	24.5	43.0	1.5	0	472.5	24.0	496.5
838	Feb. 1	3.5	do	4.3	5.3	3.0	0	67.2	48.0	115.2
837	do	2.5	Depleted	.6	.0	.2	2	4.2	3.2	7.4

WEST PASCAGOULA REEF.

This body of oysters lies on the west side of the sand spit off the mouth of West Pascagoula River, in a depth of water ranging from 2 feet on the eastern and northern edges to about 3½ feet on the west and south. It consists of an area of dense growth almost surrounded by very scattering oysters. The northern third of the bed, although prolific in young, is rated as depleted, owing to the practical absence of oysters over 3 inches long. The oysters on the bed as a whole are undersized and badly clustered.

The following table summarizes the area and conditions of oyster growth:

OYSTER GROWTH ON WEST PASCAGOULA REEF.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	71	1,261	171	89,531	12,141	101,672
Very scattering	119	177	38	21,063	4,522	25,585
Depleted	95	279	3	26,505	285	26,790
Total	285			137,099	16,948	154,047

The area of dense growth, which comprises about one-fourth of the total, undoubtedly represents the original natural growth, the surrounding less prolific area having been stocked by shells and oysters carried onto the mud by storms and waves and the involuntary agency of the oystermen. This part of the reef is extraordinarily productive, bearing an average of upwards of 1,400 bushels per acre, of which, however, the oysters over 3 inches long constitute but 12 per cent in bulk and less than 6 per cent numerically. In other words, for each oyster 3 inches or more in length, there are approximately 17 smaller ones. Several small schooners were tonging on this area at the time of the survey. The area bearing the very scattering growth of market oysters practically surrounds that just described, lying in a depth of from 2 to 3½ feet of water. It contains hardly more than 20 per cent of the quantity of large oysters per acre which occur on the dense area, but as the small oysters are relatively still less abundant those over 3 inches in length comprise about 18 per cent of the total quantity, although numerically they constitute less than 9 per cent.

The depleted bottom which covers the inshore third of the reef is practically devoid of oysters of marketable size, but in the number and quantity of small oysters it excels the area of scattering growth. The few marketable oysters are generally near the inner edge of the bed, where the oyster growth becomes very sparse. Near the outer edge of the area the young oysters are in places exceedingly abundant.

A few scattered clusters lie on the sandy bottom stretching shoreward.

The following table exhibits the results of examinations made at various stations:

DETAILS OF EXAMINATION OF WEST PASCAGOULA REEF.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	*Feet.*						*Bush.*	*Bush.*	*Bush.*
824	Feb. 1	2.8	Dense	30.0	198.0	16.7	0	1,596.0	267.2	1,863.2
825	...do	2.3	...do	26.0	111.0	8.3	3	959.0	132.8	1,091.8
828	...do	2.0	...do	19.5	156.0	7.0	8	1,228.5	112.0	1,340.5
820	...do	4.0	Very scattering	12.5	15.5	1.5	0	196.0	24.0	220.0
821	...do	3.5	...do	2.3	2.8	2.8	0	35.7	44.8	80.5
822	...do	3.2	...do	.6	1.8	1.8	0	16.8	28.8	45.6
823	...do	3.0	...do	1.6	7.2	3.7	0	61.6	59.2	120.8
835	...do	1.9	...do	9.5	72.5	2.0	0	574.0	32.0	606.0
830	...do	2.2	Depleted	4.0	123.0	.0	0	889.0	.0	889.0
832	...do	2.2	...do	.0	.5	.7	0	3.5	11.2	14.7
833	...do	2.0	...do	.0	.7	.0	....	4.9	.0	4.9
834	...do	2.2	...do	2.9	28.3	.0	1	218.4	.0	218.4

DEER ISLAND, EAST POINT BED.

This bed lies near the mouth of Biloxi Bay, north of the east end of Deer Island, in a depth of water ranging from 3 to 6 or 7 feet. It is over one-half mile long and slightly more than one-third mile wide,

and contains about 106 acres of all degrees of productiveness. Its southwest edge is indeterminate, the oyster growth being continued shoreward to or above low-water mark.

The following table summarizes the area and distribution of oyster growth on this bed:

OYSTER GROWTH ON DEER ISLAND, EAST POINT BED.

Character of growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	5	134	184	670	920	1,590
Scattering	19	21	94	399	1,786	2,185
Very scattering	35	29	40	1,015	1,400	2,415
Depleted	47	1	7	47	329	376
Total	106			2,131	4,435	6,566

The area of dense growth is a small, narrow patch of not over 5 acres in extent, which is the most prolific part of the bed in both market and small oysters. The oysters are of excellent shape and good quality. The scattering growth occupies the outer edge of the bed in a depth of from 6 to 8 feet. The market oysters vary in quantity in different places between about 75 bushels and 110 bushels per acre, and are similar in shape and quality to those on the area of dense growth, but small ones are much less numerous. The very scattering growth is inshore of the two areas previously described, and covers about 35 acres; and the depleted bottom, which occupies approximately 47 acres, borders the southern and western edges of the bed. The boundaries of this growth are indeterminate on the landward side, as scattered clusters occur in the shallow water to low-water mark or beyond.

This bed, as a whole, produces the best oysters found in Mississippi during the survey. The examinations made gave the data shown in the following table:

DETAILS OF EXAMINATION OF DEER ISLAND, EAST POINT BED.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	*Feet.*						*Bush.*	*Bush.*	*Bush.*
1232	Feb. 25	6.5	Dense	4.6	14.6	11.5	0	134.4	184.0	318.4
1227	...do	8.0	Scattering	1.0	4.0	7.0	0	35.0	112.0	147.0
1233	...do	8.0	...do	.0	.9	4.8	0	6.3	76.8	83.1
1230	...do	6.0	Very scattering	1.4	3.6	2.9	0	35.0	46.4	81.4
1231	...do	6.3	...do	.0	7.2	2.1	0	50.4	33.6	84.0
1234	...do	5.0	...do	.0	.0	2.5	0	.0	40.0	40.0
1228	...do	4.5	Depleted	.0	.6	.0	0	4.2	.0	4.2
1235	...do	5.0	...do	.0	.0	.6	0	.0	9.6	9.6
1236	...do	5.3	...do							
1237	...do	6.0	...do	.0	.0	.7	0	.0	11.2	11.2

SMALL PATCHES, BILOXI BAY.

Northwest of the bed just described and stretching as far as the railroad bridge and to the edge of the private bottoms off Red Bluff are a number of patches varying in extent from one-half acre to about 18 acres, aggregating about 73 acres of all degrees of productiveness.

The condition and extent of these fragmentary beds are summarized in the following table:

OYSTER GROWTH ON SMALL PATCHES IN BILOXI BAY.

Character of growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	5	120	277	600	1,385	1,985
Scattering	7	99	121	693	847	1,540
Very scattering	60	38	40	2,280	2,400	4,680
Depleted	1	33	8	33	8	41
Total	73			3,606	4,640	8,246

The patches bearing dense growth are four or five in number, covering, all told, about 5 acres and individually so small that to show them on the chart it has been necessary to exaggerate their size They bear between 240 and 341 bushels per acre of oysters over 3 inches long, but the stock is so badly clustered and poor as to have small value.

There are two patches of scattering oysters, covering at most about 7 acres, on which the growth resembles that just described, though less abundant. The patches of very scattering growth are more numerous and several of them are of considerable size. The boundaries of one which adjoins the private beds on the northeast side of the bay about 1¼ miles below the railroad bridge was not definitely determined, but it is estimated to contain about 18 acres. At the place examined it bore about 50 bushels of 3-inch oysters per acre and about 10 bushels of smaller ones. Another bed of about 7 acres adjoins the northeast corner of the private beds off Deer Island and bears per acre approximately 50 bushels each of oysters over and under 3 inches long.

The most extensive bed of very scattering oysters covers about 29 acres near the middle of the bay. It bears an average per acre of about 40 bushels of each of the two sizes. This bed lies on bottom such as is classed in this report as soft and very soft, and bears the appearance of having been recently established. It is said that the State planted oysters in this vicinity several years ago, and it appears probable that this is the place. The oysters are inferior and in rough clusters.

DETAILS OF EXAMINATION OF SMALL PATCHES, BILOXI BAY.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	Feet.						Bush.	Bush.	Bush.
1153	Feb. 23	5.5	Dense	1.3	26.0	21.3	0	191	341	532
1164	...do	4.3	......do	.0	11.1	15.0	0	78	240	318
1172	...do	6.5	......do	.0	5.4	17.7	0	38	283	321
1173	...do	5.3	......do	.7	24.0	15.3	0	173	245	418
1176	...do	6.5	Scattering	.0	26.4	8.6	0	185	138	323
1218	Feb. 25	8.0	......do	.0	1.7	6.5	0	12	104	116
1166	Feb. 23	5.0	Very scattering	.0	.6	2.5	0	4	40	44
1170	...do	6.3	......do	.0	9.3	2.1	0	65	34	99
1180	...do	6.5	......do	.0	5.0	4.3	0	35	69	104
1219	Feb. 25	8.0	......do	1.0	8.3	1.0	0	65	16	81
1220	...do	8.0	......do	.3	4.5	2.8	0	37	45	82
1222	...do	9.5	......do	.0	1.7	3.0	0	12	48	60
1224	...do	8.5	......do	.0	.7	1.8	0	5	29	34
1225	...do	7.0	......do	.0	4.0	1.3	0	28	21	49
1226	...do	5.5	......do	2.7	10.7	3.3	0	94	54	148
1142	Feb. 23	12.0	Depleted	.0	2.0	0	0	14	0	14
1147	...do	5.3	......do	.0	7.3	1.0	0	51	16	67

BILOXI BAY BELOW RAILROAD BRIDGE.

This bed begins close to the piers of the railroad bridge and stretches down the middle of the bay southwest of the channel for a distance of about 1½ miles. It has a maximum width of about 600 yards near its middle, tapering toward the ends, and it embraces an area of about 234 acres. At its inner edge, where it runs to, or practically to, the stakes marking the private beds, the water is about 3 feet deep, gradually increasing to from 5 to 7 feet toward the channel. It consists of a long strip of dense and scattering growth, broadly fringed on its southwest side by less prolific bottom and with an interrupted narrow belt of the same character toward the channel.

Its general condition and extent are shown in the following table:

OYSTER GROWTH IN BILOXI BAY BELOW RAILROAD BRIDGE.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	Bushels.	Bushels.	Bushels.	Bushels.	Bushels.
Dense	34	180	297	6,120	10,098	16,218
Scattering	106	140	122	14,840	12,932	27,772
Very scattering	68	39	54	2,652	3,672	6,324
Depleted	26	163	17	4,238	442	4,680
Total	234			27,850	27,144	54,994

The scattering growth occupies nearly one-half of the total area of the bed as a strip from 100 to 300 yards wide running practically the entire length of the bed. On this area there is an average growth per acre of about 122 bushels of oysters 3 inches or more

in length and a slightly greater quantity of smaller ones. Numerically the small oysters outnumber the larger ones as about 2.6 to 1.

The dense growth occupies a strip nearly a half mile long near the middle of the bed and a small patch at the lower end. On the latter, which covers about 5 acres, the larger oysters are particularly abundant, examination indicating about 416 bushels per acre. On the larger strip, which contains about 29 acres, there are about 235 bushels per acre. Oysters under 3 inches long range at the places examined between 154 and 218 bushels per acre, the average being about 180 bushels. In actual quantity the small oysters are more abundant than on the area of scattering growth, but in numbers relatively to the market oysters they are but half as abundant.

The very scattering growth and the depleted bottom lie on the edges of the bed as transition areas between the more productive and the barren bottoms. The depleted bottom, although unproductive in large oysters at the time of the survey, was well provided with small ones, the average per acre being about 163 bushels. A number of boats were tonging on this bed during the presence of the survey party in the vicinity. The oysters were of inferior quality, clustered and "coony."

DETAILS OF EXAMINATION OF BILOXI BAY BELOW RAILROAD BRIDGE.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	*Feet.*						*Bush.*	*Bush.*	*Bush.*
1151	Feb. 23	4.0	Dense	0.0	24.0	13.5	0	168	216	384
1158	...do....	5.0	.....do	1.2	30.0	16.2	0	218	259	477
1168	...do....	5.5	.....do	.0	22.0	26.0	0	154	416	570
1139	...do....	7.0	Scattering	5.3	28.6	9.3	0	237	149	386
1144	...do....	5.0	.....do	.0	21.8	7.5	0	153	120	273
1146	...do....	6.0	.....do	.0	8.6	8.6	0	60	138	198
1148	...do....	5.0	.....do	.0	9.4	8.1	0	66	130	196
1152	...do....	5.0	.....do	.0	33.8	6.2	0	237	99	336
1155	...do....	4.0	.....do	.0	16.5	8.0	0	116	128	244
1162	...do....	5.2	.....do	.0	15.6	5.6	0	109	90	199
1169	...do....	7.0								
1138	...do....	4.0	Very scattering	.0	.7	3.7	0	5	59	64
1143	...do....	6.0	.....do	.0	8.3	4.4	0	58	70	128
1150	...do....	4.0	.....do	.0	14.0	4.5	4	98	72	170
1154	...do....	4.5	.....do	3.3	1.1	3.3	0	31	53	84
1156	...do....	4.0	.....do	.0	1.0	2.0	0	7	32	39
1163	...do....	4.8	.....do	.0	5.0	2.5	0	35	40	75
1145	...do....	4.5	Depleted	.0	32.8	1.1	0	230	18	248
1149	...do....	4.0	.....do	.5	13.0	1.0	0	95	16	111

BACK BAY, EAST BED.

This bed, covering about 74 acres of bottom of varying productiveness, lies about north of the draw of the Louisville & Nashville Railroad bridge. It is about five-eighths of a mile long and about

one-quarter of a mile at its widest part. It is covered by from 3 to 3½ feet of water, with a somewhat greater depth on the barren bottom immediately adjacent to its borders. The productive bottom occupies the southern half of the bed, where a small number of tongers were at work during the survey. The oysters are badly clustered, sharp-edged, and of a poor quality.

The general condition of the bed is summarized in the following table:

OYSTER GROWTH IN BACK BAY, EAST BED.

Character of growth.	Area.	Oysters per acre		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	29	113	249	3,277	7,221	10,498
Scattering	6	62	88	372	528	900
Very scattering	18	228	56	4,104	1,008	5,112
Depleted	21	47	11	987	231	1,218
Total	74			8,740	8,988	17,728

The area of dense growth covers about 29 acres, on which there are about 249 bushels of oysters over 3 inches long and 113 bushels of smaller ones per acre. Numerically the two classes are practically equal, that is, there is a young oyster for every one above 3 inches long. In some places the bottom is fairly compact and in others the oysters lie on soft black mud with many buried shells. The oysters are generally in large rough clusters.

The scattering growth lies as a narrow strip on the eastern edge of the preceding and covers about 6 acres. The young oysters are more numerous in proportion to the large ones, but both are in smaller quantity than on the dense part of the bed.

On the area of very scattering growth, while the market oysters are less numerous the young are found in greater quantity than on the other parts of the bed. For each oyster over 3 inches long there are more than 9 smaller ones. The clusters contain numerous individuals, and it is apparent that the conditions are such as to retard their growth. The bottom is hard on the surface. The depleted bottom occupies the gradually narrowing northern end of the bed and is deficient in oysters of all sizes.

The following table gives the details of the examination made on the bed:

Details of Examination of Back Bay, East Bed.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	*Feet.*						*Bush.*	*Bush.*	*Bush.*
1189	Feb. 24	4.0	Dense	.0	41.5	15.5	0	290.5	248.0	538.5
1190	...do	4.5	......do	.0	5.5	13.3	0	38.5	212.8	251.3
1191	...do	6.0	......do	.0	1.4	17.8	0	9.8	284.8	294.6
1188	...do	4.5	Scattering	2.2	6.7	5.5	0	62.3	88.0	150.3
1203	...do	4.0	Very scattering	.0	19.5	3.0	0	136.5	48.0	184.5
1204	...do	4.0	......do	.0	45.5	4.0	0	318.5	64.0	382.5
1205	...do	4.2	Depleted	.0	13.5	.5	0	94.5	8.0	102.5
1207	...do	3.8	......do	.0	4.0	.5	0	28.0	8.0	36.0
1208	...do	4.3	......do	.0	2.8	1.1	0	19.6	17.6	37.2

BACK BAY, WEST BED.

This bed begins about a quarter of a mile nearly west of the draw in the railroad bridge and stretches along the northern edge of the main channel for a distance of about three-fourths of a mile, its northwestern edge adjoining the boundary stakes of the planted beds. The water varies from less than 3 feet near the eastern end of the bed to about 10 feet at the western edge. Among the beds of Biloxi Bay this is distinguished by the abundance of small oysters.

The following table summarizes the areas, character of growth, and general condition of the several parts of the bed:

Oyster Growth in Back Bay, West Bed.

Character of growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	29	279	214	8,091	6,206	14,297
Scattering	5	35	136	175	680	855
Very scattering	41	381	55	15,621	2,255	17,876
Depleted	20	14	1	280	20	300
Total	95	....	....	24,167	9,161	33,328

The area of dense growth is a narrow strip extending nearly the entire length of the bed and for a considerable part of the distance near its northeast edge, forming a ridge covered by very shallow water. It covers about 29 acres and bears an average per acre of 214 bushels of market oysters and 279 bushels of small ones. There are about three small oysters to each one over 3 inches long. The stock is generally of poor shape and quality and badly clustered. The area of scattering growth lies between the eastern edge of the preceding and the margin of the bed. There is a fair quantity of the larger oysters but a dearth of small ones.

The very scattering growth lies in two areas, one of about 13 acres, occupying the southern margin of the bed adjoining the channel, and the other of about 28 acres at the western end of the bed. The examination of the former indicated about 70 bushels of larger oysters and 183 bushels of smaller ones per acre. The larger area at the western end of the bed has per acre only 50 bushels of oysters over 3 inches, but is much more productive in small ones, especially in that portion which adjoins the dense growth, where examination indicated 1,120 bushels per acre. This prolificness covers but a small area and the production of both large and small oysters decreases toward the boundary stakes of the planted beds.

The depleted bottom, of which there are two areas, shown on the chart, is almost bare. The following examinations were made:

DETAILS OF EXAMINATION OF BACK BAY, WEST BED.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911	*Feet.*						*Bush.*	*Bush.*	*Bush.*
1193	Feb. 24	3.5	Dense	0	7.7	10.4	0	53.9	166.4	220.3
1196	...do....	10.0	......do	0	65.4	13.6	0	457.8	217.6	675.4
1214	...do....	4.0	......do	0	30.0	22.0	0	210.0	352.0	562.0
1215	...do....	4.0	......do	0	56.5	7.5	0	395.5	120.0	515.5
1192	...do....	4.0	Scattering	0	5.0	8.5	0	35.0	136.0	171.0
1194	...do....	3.0	Very scattering	0	26.2	4.4	0	183.4	70.4	253.8
1197	...do....	6.0	......do	0	160.0	3.6	0	1,120.0	57.6	1,177.6
1198	...do....	4.5	......do	0	12.8	2.2	0	89.6	35.2	124.8
1199	...do....	6.0	......do	0	18.6	3.6	0	130.2	57.6	187.8
1213	...do....	3.8	Depleted	1	2.0	.1	0	14.7	1.6	16.3
1216	...do....	5.0	......do	0	1.9	.0	0	13.3	.0	13.3

THE BEDS IN SUMMARY.

The natural oyster beds of Mississippi east of Biloxi are restricted to the waters adjacent to the mouth of the Pascagoula River and Biloxi Bay. The beds of the former locality, of which there are two and some insignificant patches, embrace almost exactly two-thirds of the naturally productive bottom; Scranton Reef, the larger of the beds, comprises nearly one-half of the oyster area of the region surveyed, and West Pascagoula Reef about one-sixth. The two, with the small patches alluded to, cover about 1,126 acres, of which 115 acres have a dense growth of oysters of marketable size, 115 acres a scattering growth, 531 acres a very scattering growth, and 365 acres are so sparsely covered as to be classified as depleted. All of these lie in water not exceeding 5 feet in depth and most of them, especially the more productive parts, are covered by 3 feet or less.

In Biloxi Bay there are four beds of more than insignificant size. The largest of these, covering about 234 acres, lies on the west side below the railroad bridge. The others in the order of their areas

are near the southeastern end of Deer Island, and the western and eastern beds, respectively, above the railroad bridge. In addition there are a number of small patches below the railroad bridge, the largest of which is believed to be a public planted bed. Altogether there are in Biloxi Bay about 582 acres of oyster bottom, of which 102 acres are classed as dense, 143 as scattering, 222 as very scattering, and 115 as depleted. Of the entire area of 1,708 acres of natural oyster bottom located by the survey, 13 per cent is covered by a dense growth of oysters of marketable size, 15 per cent by a scattering growth, 44 per cent by a very scattering growth, and 28 per cent is depleted or very deficient in such oysters.

The following table summarizes the distribution of the oysters on the several beds:

SUMMARIZED STATEMENT OF AREAS OF MARKET OYSTERS ON PUBLIC BEDS.

Name of bed.	Character of oyster growth.				Total.
	Dense.	Scattering.	Very scattering.	Depleted.	
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Scranton Reef	44	105	402	262	813
Patches near Scranton Reef	....	10	10	8	28
West Pascagoula Reef	71	....	119	95	285
Deer Island, East Point	5	19	35	47	106
Small patches, Biloxi Bay	5	7	60	1	73
Biloxi Bay, below railway bridge	34	106	68	26	234
Back Bay, east bed	29	6	18	21	74
Back Bay, west bed	29	5	41	20	95
Total	217	258	753	480	1,708

It should be understood that the foregoing classification in respect to relative density of oyster growth is based solely on the quantity of oysters 3 inches or more in length irrespective of the quantity of small oysters present. The classification, furthermore, represents the condition at the time of examination and the several classes may and undoubtedly will undergo redistribution from time to time. The areas of dense growth may become less productive from overfishing or other causes while a heavy set of spat may bring the lower classes into increased productivity and raise them a step higher in the scale. In some cases the number of young oysters on the beds at the time of examination was sufficient to produce this effect in the following year. On the whole, however, the general conditions shown in this report, barring accidents, should be maintained for a period of years. The estimated total content of oysters over 3 inches long on the several parts of the different beds is shown in the table following.

Summarized Content of Market Oysters on Public Beds.

Name of bed.	Character of oyster growth.				Total.
	Dense.	Scattering.	Very scattering.	Depleted.	
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Scranton Reef	12,232	12,285	18,894	2,358	45,769
Patches near Scranton Reef	....	770	360	24	1,154
West Pascagoula Reef	12,141	....	4,522	285	16,948
Deer Island, East Point	920	1,786	1,400	329	4,435
Small patches, Biloxi Bay	1,385	847	2,400	8	4,640
Biloxi Bay, below railway bridge	10,098	12,932	3,672	442	27,144
Back Bay, east bed	7,221	528	1,008	231	8,988
Back Bay, west bed	6,206	680	2,255	20	9,161
Total	50,203	29,828	34,511	3,697	118,239

Fifty-four per cent, or 63,871 bushels of the larger oysters disclosed by the survey were found in the region adjacent to the mouth of Pascagoula River. Of these, 24,373 bushels were in dense growth, 13,055 bushels scattering, 23.776 bushels very scattering, and 2,667 bushels on the depleted bottom. The remaining 54,368 bushels, constituting about 46 per cent of the total, were in Biloxi Bay, where 25,830 bushels occurred as dense growth, 16,773 bushels as scattering, 10,735 bushels as very scattering, and but 1,030 bushels were on the so-called depleted bottom.

The average product per acre on the beds near Pascagoula River was 221 bushels on the dense, 113 bushels on the scattering, 45 bushels on the very scattering, and 7 bushels on the depleted bottoms.

In Biloxi Bay the averages are 249 bushels per acre on the dense growth, 117 bushels on the scattering, 48 bushels on the very scattering, and 9 bushels on the depleted bottom. It is therefore evident that the oysters on the areas classed as very scattering and depleted are so sparsely distributed that they are at present negligible commercially on account of the time and labor which would be involved in tonging them. About 72 per cent of the oyster producing bottom is, therefore, to be regarded as of no present producing value. The remaining 28 per cent of the area of the beds produces oysters in sufficient quantity to warrant a fishery if size only is considered, but many of the oysters are so badly clustered and so inferior in quality that they have very little value. This is particularly the case on Scranton and West Pascagoula Reefs.

The only good oysters seen in that vicinity were in the deep water of Pascagoula River, where singles and small clusters are taken in limited quantity. In Biloxi Bay not only is the average productiveness of the dense and scattered growth greater, but the areas of these growths are greater in proportion to the total extent of the beds, and the oysters are of somewhat better quality.

The dense and scattered growths, but especially the former, are doubtless somewhat more prolific than is estimated in this report, as where the oysters are very rank the tongs in many cases do not take up all within the extent of the "grab," and as the estimates are based on the area covered by the open tong heads and the number of oysters brought up in a definite number of grabs, there is certainty of an underestimate. On less prolific bottom this error does not occur. It should be stated that the bushel employed, while of the legal dimensions, contains more than the trade bushel, because to secure uniformity of results the oysters are culled into singles or doubles and carefully packed in the measure. It is estimated that it holds, for this reason, 25 to 30 per cent more than when filled in the ordinary way. The small oysters, on which the future of the beds is in large measure dependent, differ from the larger oysters very materially in their distribution, as is shown in the following table:

SUMMARIZED CONTENT OF YOUNG OYSTERS ON PUBLIC BEDS.

Name of bed.	Character of oyster growth.				Total.
	Dense.	Scattering.	Very scattering.	Depleted.	
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Scranton Reef	32,560	46,935	82,812	7,074	169,381
Patches near Scranton Reef	....	2,070	2,700	32	4,802
West Pascagoula Reef	89,531	....	21,063	26,505	137,099
Deer Island, East Point	670	399	1,015	47	2,131
Small patches, Biloxi Bay	600	693	2,280	33	3,606
Biloxi Bay, below railway bridge	6,120	14,840	2,652	4,238	27,850
Back Bay, east bed	3,277	372	4,104	987	8,740
Back Bay, west bed	8,091	175	15,621	280	24,167
Total	140,849	65,484	132,247	39,196	377,776

It will be observed that in the entire region surveyed there is over three times the quantity of small oysters as of large ones, but if the table be subjected to analysis it will be found that they are very unequally distributed between the Pascagoula and Biloxi localities. Of the total 377,776 bushels, 311,282 bushels, or over 82 per cent, are found in the former, and but 66,494 bushels, or less than 18 per cent, in the latter. In the former there is nearly five times the quantity less than 3 inches long that there is of larger ones, while in Biloxi Bay there is but little difference. On Scranton and West Pascagoula Reefs and the adjacent small patches there are averages of 1,061 bushels per acre on the dense growth, 426 bushels on the scattering, 200 bushels on the very scattering, and 92 bushels on what is called depleted bottom. In other words, for every bushel of oysters of market size there are on the dense areas 4.8 bushels of small ones, on the scattering growth 3.8 bushels, on the very scattering growth 4.4 bushels, and on the depleted bottom 13 bushels.

On the beds of Biloxi Bay, taken as a whole, the dense areas contain 184 bushels of small oysters per acre, the scattering 115 bushels, the very scattering 115 bushels, and the depleted 48 bushels. Comparing the quantity of small and large oysters, the areas of dense growth have 0.7 bushel of the former to each bushel of the latter, the scattering growth 1 bushel, the very scattering growth 2.5 bushels, and the depleted bottom 5.6 bushels.

As it requires more small oysters than large ones to make a bushel, and as the value of the small ones depends upon their potentiality to grow into large ones, the proportion between the numbers of small and large is of more importance than the comparison of their quantities. This proportion for each class of growth on each bed is shown in the following table:

NUMBER OF OYSTERS UNDER 3 INCHES LONG FOR EACH ONE OVER THAT LENGTH ON THE SEVERAL BEDS.

Name of bed.	Character of oyster growth.			
	Dense.	Scattering.	Very scattering.	Depleted.
Scranton Reef	6.07	8.70	10.12	7.28
Patches near Scranton Reef	....	6.16	17.13	3.00
West Pascagoula Reef	16.89	....	10.70	227.71
Deer Island, East Point	1.67	.50	1.62	.46
Small patches, Biloxi Bay	.99	1.86	2.20	9.30
Biloxi Bay, below railway bridge	1.38	2.62	1.63	22.00
Back Bay, east bed	1.03	1.62	9.28	9.66
Back Bay, west bed	2.98	.59	15.76	40.00

Analyzing this table by regions, it is found that on the beds in the vicinity of Pascagoula River for every oyster 3 inches or more in length there are on the dense growth about 11 small ones, on the scattering 8, on the very scattering 11, and on the depleted bottom 28. Most of these are between 2 and 3 inches long. On the beds in Biloxi Bay there are respectively 1.6 small oysters to each large one on the dense growth, 2 on the scattering growth, 5.3 on the very scattering growth, and 12 on the depleted bottom.

In Biloxi Bay the proportion of small to large oysters is in no way unusual. On the areas of dense and scattering growth the proportions are such as indicate a normal condition of the beds, although there is a deficiency of small oysters on the scattered growth of Deer Island and Back Bay west beds. The high proportion of young on the depleted areas of certain beds is due not to their unusual abundance but to the scarcity of the larger ones with which they are compared, as may be seen by the detailed tables contained in the descriptions of the individual beds.

On the beds at the mouth of Pascagoula River the condition is different. There the small oysters are superabundant almost every-

where. There appear to be three conceivable explanations of this preponderance—(*a*) an extraordinary set of spat in the year preceding the survey following the destruction of the beds by freshets or other causes, (*b*) an unusually heavy set of spat without the destruction of the mature oysters, and (*c*) an average condition with respect to spat production, but general conditions of environment which prevent or retard the normal growth of the oysters.

Judging from the appearance of the reefs and such information as it was possible to obtain concerning their history it appears that the third is the true explanation of the unsatisfactory state of the oysters. While the spatting conditions are good there is apparently a deficiency of the food requisite for the growth and fattening of the dense oyster population. The oysters are crowded in clusters and the individuals are unable to secure the requisite amount of nutriment. The planting of oysters on the bottom adjoining the original bed of Scranton Reef accentuated the trouble and was ill advised. Better success probably would have attended planting in deeper water and where the tidal flow is stronger.

These beds densely crowded with small and inferior oysters are of no immediate commercial value. Apparently their only use is for seed beds from which the small oysters might be transplanted to localities more favorable for growth.

BARREN BOTTOMS.

The area of barren bottoms—that is, those which are not naturally productive of oysters even in small quantities—vastly exceeds that of the natural beds, including in the latter those so-called depleted areas which bear practically nothing. These bottoms are barren, mainly because of one character in which they differ from the productive areas—namely, that they are devoid of shells or other objects lying on the surface. They consist of sand and mud of varying degrees of stability and consistency. Oysters, immediately after they develop from the egg, for a brief period swim or float freely in the water, settling to a fixed condition only after they reach a stage of considerable development.[a]

It is not necessary to give more detail to this subject other than to say that at the time at which they are undergoing fixation the oysters are very minute, and a slight film of mud or slime is sufficient to stifle them. During the spawning season these little organisms are present in the water in untold myriads and are precipitated to the bottom in a continuous gentle drizzle of tiny specks. If they fall on an oyster bed they find firm supports on the shells and oysters, attach themselves and grow, but if they fall on the mud or bare sand they die.

[a] For a more extended account see "Oysters and methods of oyster culture," by H. F. Moore, Bureau of Fisheries Document 349, which may be obtained by application to the Bureau at Washington, D. C.

The natural beds have been slowly developed on bottom similar to that which surrounds them solely because through some agency there originally lodged on the mud or sand some hard objects to which the young oysters could safely cling. Oysters developing there and their shells scattered about by the waves furnished additional places for fixation of new generations of young, with the result that the original growth extended in area and its bed became a compact mass of shells and fragments, beneath which can still be found by excavation or probing the original bottom differing in no essential particular from the adjacent barren areas.

All that is required by the barren bottom in order that it may become productive is that its surface should be supplied with hard objects or cultch, either through natural agencies or by the hand of man. The capacity of the bottom to sustain material deposited on it and to maintain it in proper condition to serve as cultch depends largely on its stability and consistency. Moving sands gradually cover objects deposited on their surface and soft mud permits them to sink. It is therefore of prime importance for the oyster culturist to have information concerning the character of the bottom, and it was one of the purposes of the survey to supply it.

The methods and the instrument employed have been described in the introductory part of this report and the results attained are shown graphically on the chart.

The symbols on the chart designating the character of the bottom do not show all of the places at which examinations were made. They were merely representative of the general characteristics in their vicinity with respect to the bottom deposits. It will be observed that the chart shows, in general, a gradually increasing softness of the bottom toward the middle of the sound. The survey in the adjoining part of Alabama demonstrated that the very soft or oozy mud extends nearly to the islands on the south, adjoining which there is a narrow strip of sand, and, in view of the apparently similar conditions in Mississippi and the limited time at the disposal of the party, it was deemed unnecessary to continue the examinations beyond the line at which it was evident that the bottom was growing too soft for oyster culture.

Excluding the shoal waters near shore, which it is understood are to a considerable extent subject to the control of riparian owners, the firmer bottom lies within five general areas, embracing about 23,000 acres, which are described as follows:

Grand Batture Shoal.—This shoal extends in a curve, concave, toward the east, from the west end of Grand Batture Spit to a beacon in about 8 feet of water near the middle of the sound. The shoal itself lies in a depth of 6 feet or less and is composed of more or less shifting sand, apparently too unstable for oyster culture, but sur-

rounding it, especially between its eastern margin and the Mississippi-Alabama line, the sand is mingled with sufficient mud to give it the required consistency. This firm bottom lies in a depth of between 8 and 12 feet and covers an area of about 4,200 acres. It is fairly well protected from freshets and is of a character which should permit it to be worked with dredges.

Point aux Chenes.—Lying south and southwest of the western half of Point aux Chenes is a strip of stiff and soft mud stretching from the hard sand fringing the shore to a distance of about 1½ miles from land and with a length of upward of 2 miles east and west. Its western extremity is near Beacon B marking the approach to Pascagoula. The depth of water ranges from 6 to 13 or 14 feet and the area of the tract is about 2,000 acres. This bottom is softer than that previously described, but a considerable part of it is suitable for planting either oysters or cultch. Its proximity to the mouth of Pascagoula makes it susceptible to the influences of freshets.

East of Round Island.—Adjacent to Round Island, especially on the east and south sides, is a sandy shoal gradually merging with the surrounding mud. The sandy bottom in depths of less than 5 or 6 feet appears to be shifting, but in the deeper water to the eastward toward the Pascagoula Channel there is sufficient mud to serve as a "binder," and enough sand to correct the excessive plasticity of the mud. In consistency this bottom varies from "hard" to "soft," most of it being what is designated in this report as "stiff." This area, which covers about 1,300 acres, is open to the same objection as the area of Point aux Chenes—its exposure to the effects of freshets owing to its proximity to the mouth of Pascagoula River.

Off Bellefontaine Coast.—From about 1 mile west of the mouth of Graveline Bayou there is a strip of more or less hard bottom stretching almost without interruption to Biloxi Channel, but for convenience of description it appears advisable to divide it at the shoal running from the east end of Deer Island. The portion here described is a curved strip about 5 miles long and from 1 to 3 miles wide encircling the shoal projecting from Bellefontaine Coast. It lies in water from 6 to 11 feet deep and varies in consistency from stiff to soft. In shoaler water the bottom is composed of hard sand liable to shift and in deeper water the mud is too soft. Owing to its proximity to Dog Keys Pass and its relative remoteness from large fresh-water affluents, it is subject to less danger than the preceding two localities in times of flood. It covers an area of approximately 6,500 acres.

Off Deer Island.—This area stretches from the western end of the preceding to the dredged channel leading to Biloxi, outside the sandy area fringing the shore and forming a bar at the eastern end of the island. In depths less than 6 feet the bottom probably shifts more or less under the influence of waves and currents, and is therefore

hazardous for oyster culture, although a few natural growth oysters are found on it in places. In depths between 6 and 9 or 10 feet, and probably somewhat greater, there is a good stiff and soft bottom, most of the area falling within the former classification. Although it is impossible to determine definitely without actual practical experiment, this area, which covers upward of 9,000 acres, appears to be well adapted to oyster culture. The streams discharging in its immediate vicinity are comparatively small, and it is in proximity to Dog Key and Ship Island Passes, therefore being guarded to a considerable extent from destructive reduction of salinity during freshets. The greater salinity might invite the inroads of drills or conchs, but this danger could be somewhat minimized by planting seed oysters rather than cultch.

GENERAL PHYSICAL AND BIOLOGICAL CONDITIONS.

TIDES AND CURRENTS.

During the hydrographic and biological survey tide gauges were maintained at Pascagoula and Biloxi. The former was a plain staff, graduated in feet and tenths, established at the end of the boathouse at the light keeper's house at the mouth of the Pascagoula River. The automatic gauge established by the United States Army engineers was out of order and there was no bench mark available for reference. Mean low water was established by readings from February 7 to March 14, and by comparison with observations made simultaneously during 20 days at Biloxi.

At Biloxi a similar gauge was observed from February 21 to March 12, the mean low water being established by reference to the United States engineers' gauges on channel beacons A and D, which have been referred by leveling to the United States Coast and Geodetic Survey bench mark.

The observations were made primarily for the correction of the soundings, and as the daily tidal range is small, usually about 18 inches, they are of little interest in connection with oyster culture or the fishery. The tidal currents in the region are more or less modified in velocity and duration by the winds, which often mask the lunar tides. In general the currents are sufficient to maintain the distribution of oyster food.

SALINITY OF THE WATER.

The quantity of saline matter in solution in the water is an important factor in determining the growth and character of oysters. If salt be absent entirely, or if its quantity be as great as that carried by the waters of the open sea, oysters will not live, and as these two extremes are approached the adverse effects are seen in the stunted

or otherwise inferior character of the oysters produced. The effects of the salinity of the water are not restricted to the direct influence on the oysters, but may affect them indirectly by furthering or retarding the occurrence of enemies and growths inimical to them. The conch, or drill, for instance, does not thrive in water having a low salt content, while, on the contrary, mussels, the vigorous growth of which is highly detrimental to oysters, often flourish in low salinities.

During the survey the specific gravity of the water was tested thrice daily on the *Fish Hawk* and in addition several observations were made each day by the party actually working on the beds. The following table summarizes the results of these observations:

Specific Gravity of Water at Various Places and Dates.

Locality.	Date.	Average temperature.	Average specific gravity.	Maximum specific gravity.	Minimum specific gravity.
	1910–11	°F.			
Off Point aux Chenes	Feb. 9–11	63	1.0190	1.0204	1.0164
	Feb. 14–16	67	1.0170	1.0194	1.0129
Pascagoula, Miss.	Dec. 24–27	49	1.0196	1.0209	1.0187
	Jan. 20–24	61	1.0122	1.0154	1.0106
	Jan. 29–31	65	1.0169	1.0188	1.0152
	Feb. 1–4	67	1.0121	1.0156	1.0063
	Feb. 5–8	71	1.0136	1.0173	1.0075
	Feb. 12–14	61	1.0136	1.0180	1.0084
	Mar. 6–8	66	1.0168	1.0178	1.0139
	Apr. 2–4	70	1.0152	1.0190	1.0140
Three miles south of Graveline Bayou	Feb. 16–18	68	1.0175	1.0194	1.0133
	Mar. 13–14	65	1.0209	1.0210	1.0208
Three miles off Biloxi Bay	Feb. 19	70	1.0178	1.0207	1.0138
Three miles southwest of Deer Island	Mar. 4–6	63	1.0189	1.0196	1.0182
	Mar. 8	69	1.0198	1.0212	1.0184
	Mar. 11–13	71	1.0193	1.0203	1.0187
Biloxi	Feb. 20–23	54	1.0151	1.0177	1.0118
	Feb. 24–27	58	1.0150	1.0156	1.0129
	Feb. 28–Mar. 3	63	1.0170	1.0186	1.0127
	Mar. 9–10	68	1.0187	1.0192	1.0182

This table embraces observations made at intervals between December 24, 1910, and April 4, 1911, part of the period, from January 20 to March 10, being covered with practically no interruption. During this time the specific gravity varied from a maximum of 1.0210 off the mouth of Graveline Bay on March 14 to a minimum of 1.0063 at Pascagoula on February 4, and the local averages for periods of several days ranged with time or place between 1.0209 off Graveline Bayou on March 13 and 14 to 1.0121 at Pascagoula on February 1 to February 4. These figures compare with fresh water as 1.0000 and ocean water as 1.0250 or 1.0260. The minima shown in the table all occurred at low water and the maxima at or near high water. The lowest readings were taken in Pascagoula River, the station being located at the railroad bridge, where there was a considerable difference between the salinity of successive high and low waters. The highest average, as well as the lowest daily fluctuation,

was found off Deer Island, near Biloxi. Nowhere during the survey was the salinity above or below that which oysters will tolerate, although in Pascagoula River it sometimes fell below that at which good marketable stock is ordinarily produced. In times of prolonged and very heavy rainfall undoubtedly the water in Pascagoula River becomes entirely or practically fresh, and the influence of its discharge must be felt in a pronounced reduction of the salinity of the sound near its mouth.

OYSTER FOOD.

In reports on previous surveys a feature usually has been made of the subject of the quantity of oyster food carried by the waters. These discussions have been confined, practically, to diatoms, minute microscopic plants, which authors generally have been prone to regard as supplying practically all of the oyster's nutriment. Volumetric studies of the micro-organism content of the water begun in connection with the survey of Matagorda Bay [a] in 1905 revealed a quantity so small as to excite the author's suspicion that the living matter was of less relative importance than had been generally supposed.

It appeared possible, however, that the quantity of water filtered by the oyster might be greater than generally supposed and digestion more rapid, and that despite appearances the small quantity of microscopic living organisms in the water and present in the stomach at any one time might be sufficient material for the growth and general physiological activities of a sluggish animal like the oyster.

To test the matter, apparatus and methods [b] were devised for the volumetric determination of the organisms actually eaten during comparable periods of time. The result of this work, which has been carried on at intervals for several years by the author and Mr. T. E. B. Pope, has shown that while the quantity of water filtered is great, averaging roughly about 30 quarts daily for oysters 4½ inches long, the volume of the living food is insufficient to account for the actual growth of the oyster, making no allowance for the requirements of other vital activities. It appears that finely divided organic debris or detritus, which constitutes the major part of the material ingested, plays a more important role in the oyster diet than has been conceded, a view which recently has been advanced by Petersen and Jensen.[c]

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[a] Survey of oyster bottoms in Matagorda Bay, Tex. By H. F. Moore. Report of the Bureau of Fisheries, 1905. Bureau of Fisheries Document No. 610.

[b] Volumetric studies of the food and feeding of oysters. By H. F. Moore. (Proceedings of the Fourth International Fishery Congress, Washington, 1908.) Bulletin, Bureau of Fisheries, vol. XXVIII, 1908, pp. 1295–1308.

[c] Valuation of the sea. I.—Animal life of the sea bottom, its food and quantity. By C. G. Joh. Petersen and P. Boysen Jensen. Report of the Danish Biological Station, XX. Copenhagen, 1911.

In view of these facts and probabilities, and the present impossibility of establishing a standard for the expression of the quantity of food available, the data respecting the food content of the water collected during this survey will not be stated here. A special paper on the entire subject of the food and feeding of oysters will be issued on the completion of the studies.

It may be stated from observation of the oysters and on general grounds that the food supply in Mississippi Sound and minor contiguous waters is ample.

OYSTER ENEMIES.

As the survey was carried on during the early spring, when the water was still comparatively cold, the observations made are probably not to be regarded as a reliable index to the abundance of oyster enemies. None were observed but a few drills, mostly small, and an insignificant number of mussels. The low temperature of the water could have had but little effect on the latter, and it is fair to assume that ordinarily they are nowhere present in sufficient numbers to prove seriously detrimental to the oysters.

As observations on other parts of the Gulf coast have shown that certain enemies to the oyster are of general occurrence, it appears advisable to furnish some general information respecting them.

Drill, borer, snail, whelk, conch (*Purpura hæmostoma*).—This animal, which bears these several names on the Gulf coast, was found very sparingly during the survey in Mississippi waters, and there was little other indication of its presence. A few small ones were taken on Scranton Reef and in Biloxi Bay, but in neither place was there found a sufficient number of drilled oyster shells to indicate that it had been recently abundant. It is liable to occur, however, especially in the more saline water, and care should be exercised not to introduce it with seed oysters from infested beds.

The drill or whelk lays its eggs in red or purple leathery capsules about one-half inch long and attached in clusters to shells, snags, and other firm bodies in the water. The young become destructive to the minute spat immediately upon emerging from the egg cases; they grow rapidly and progress in destructiveness as they increase in size. They destroy the oysters by drilling a small round hole through the shell, using for the purpose a flexible rasp-like organ lying at the end of a protrusible proboscis. After the shell is perforated the proboscis is thrust into the shell and the contents eaten, other drills sometimes partaking of the feast by entering the gaping shell of the dead or dying oyster. Most of the oysters destroyed are under 2 inches long, but large drills often kill more adult oysters.

Mussels.—The common black sea mussel is a passive enemy of oysters, through its tendency to attach to them and under favorable

conditions to grow so rapidly and in such numbers as to completely cover and stifle them. Also, as its food is the same as that of the oyster, its abundance reduces the supply and in that way deprives the oyster of the nutriment required to make it fat and marketable. Even when neither of these effects are important, mussels injure the fishery, owing to the tenacity with which they are anchored to the oyster, which increases the labor of culling and makes the oyster so unsightly from the adhering fibers of the byssus as to considerably reduce its market value if sold as shell stock. The conditions which make for the abundance of the mussel are not thoroughly understood, but on the Gulf coast it appears to be controlled largely by the saltness of the water, the mussels generally flourishing where the salinity is low for prolonged periods. Comparatively few were found in the region surveyed, and it is probable that they never or rarely become troublesome on account of the high salinity frequently occurring.

Drumfish (*Pogonias cromis*).—This, the "black drum," was not observed during the survey, but it is a destructive enemy of the oyster in other parts of the Gulf coast and is reported to destroy oysters on the adjacent beds of Alabama. It is migratory, making sudden forays and leaving, with destruction in its wake, often before its presence has been noticed. It destroys the oysters by crushing them between the stout grinding teeth or bones with which its mouth is furnished, and it is peculiarly destructive to the better grade of planted beds on which the oysters have been culled and separated to permit them to grow and improve in shape and quality. It is especially likely to attack the culled oysters within a few weeks of the time when they are planted, but they are not immune at any time. In Louisiana the drumfish is so destructive in places that the oystermen find it necessary to exclude them by surrounding their bedding grounds with wire fences.

Oysters in the natural beds, especially when they are much clustered and of the sharp-edged raccoon type, are rarely injured seriously, as the sharp edges of the shells, presented in all directions, lacerate the lips and mouth of the fish and deter them from extensive destruction. Occasionally the small oysters culled off by the oystermen are damaged.

The drumfish occurs in waters of all degrees of salinity, from fresh or practically fresh to full oceanic density.

SPAWNING.

The survey was conducted at the season when the reproductive functions of the oysters are in abeyance, and therefore no definite statement of the spawning season in Mississippi can be made. Various investigations carried on by the Bureau at the western end of

Mississippi Sound, where the general conditions affecting spawning are essentially the same as at the eastern end, make it possible to indicate with some precision the period during which the spawn is likely to be emitted:

It is probable that the eggs may ripen even in the winter during sustained warm periods, but it is doubtful in these cases, even though the eggs be fertilized, if development ever proceeds far enough to secure a set of spat. The normal spawning probably occurs from April to October, as it does in similar waters in Louisiana, and clean shells or other cultch planted during those months should receive a good set of spat. The young oysters are free-swimming organisms during a short period of their early life, and as they are produced in untold myriads on the crowded natural beds and carried considerable distances by the currents, the water over a large part of the sound must be teeming with the fry during the favorable part of the year. Most of these embryo oysters perish through falling on unsuitable bottom at the stage of the shell formation when they are still barely visible to the unaided eye, and may be stifled by an exceedingly thin deposit of mud or slime. Those fortunate enough to alight on shells or other oysters and similar firm supports survive in large numbers, as is witnessed by the crowded condition of the beds, but over the vastly greater proportion of the bottom there is nothing to afford a haven. The only fundamental difference between an oyster bed and the surrounding barren bottom is that the former presents places for the attachment of the spat and the latter does not.

Many free-swimming oyster fry are also killed by sudden drops in temperature, though this is not common on the Gulf coast, and by heavy rainfalls. The latter also tend to retard or suspend spawning through lowering the salinity of the water, and it frequently happens that heavy freshets defer spawning until summer. As freshets usually leave the shells and other cultch in excellent condition so far as cleanliness is concerned, probably through the destruction of slime-producing organisms, it frequently happens that a late spawning season produces an enormous set.

OYSTER CULTURE.

Oyster culture in the sense employed on the Atlantic and Pacific coasts and in some of the Gulf States is almost negligible of consideration, as at present practiced in Mississippi. The State conducts planting operations on the public bottoms, expending large sums annually during the years 1908 to 1911 in depositing oysters and shells on the reefs and adjacent barren bottoms, but there is very little oyster planting under private auspices, and none at all excepting under rights accruing to riparian owners. In 1911, but 4 per cent of the oysters produced in the State came from private beds, a smaller

proportion than in any other Gulf State excepting Texas. In Louisiana, in the same year, 44 per cent of the oysters produced were grown on bottom rented from the State, and the yield from this source alone was three times the quantity, and over four times the value, of the entire product of Mississippi.

Most of the planting by the State was west of the region covered by the survey, but large quantities of shells and oysters have been deposited on Scranton Reef and the Biloxi Bay beds, the condition of which was developed during the present investigation, and is presented in some detail in the preceding part of this report. It is the opinion of the author that the survey developed the almost complete futility of the State's policy so far as the region east of Biloxi is concerned. Pascagoula or Scranton Reef, and West Pascagoula Reef were practically worthless as market oyster producers during the winter and spring of 1910–11. During a considerable period of observation no boats, excepting one or two small skiffs, were seen on the former, and but one schooner on the latter. The oysters were badly clustered, ill shaped, and poor in every way. During the calendar year 1911 about 28,000 bushels of oysters were taken by small boats from the vicinity of Pascagoula. Some of these came from the Pascagoula River, where they are of good quality, and the remainder are reported to have come from the adjacent reefs.

In Biloxi Bay the conditions are somewhat better, but still poor. Deer Island bed produces fairly good oysters, but on all of the other beds the stock was rough, clustered and generally inferior, although the presence of a number of tongers on the large bed below the railroad bridge and on the east bed above the bridge indicates that it finds some market.

The laws of Mississippi do not permit the lease of barren bottoms for oyster culture, but in its report for 1911 the Board of Oyster Commissioners recommended "that they be given the right by law to lease to private individuals, firms, and corporations, citizens of the State, for a term of years to be fixed by the legislature, barren bottoms suitable for planting oysters, on such terms and at such prices as the legislature may fix." With this recommendation the author is in hearty accord, but he believes that the further suggestions that the extent of the leaseholds be limited to 100 acres for each person, firm, and corporation, and that the annual rental be fixed at $1 per acre are not sufficiently liberal. Although this survey indicates that in the region covered upwards of 23,000 acres of the bottom are presumptively suitable for oyster culture, it should be remembered that until practical test is actually made there is no conclusive evidence that they are suited for the purpose. For this reason the first plantings must be in the nature of experiments with the possibility of failure. In view of this, and to induce the undertaking, the rental

during the first few years should be low, gradually increasing to a maximum of $1 per acre after time has been granted for the determination of the commercially feasibility of the project under any given lease. If the practicability of private oyster culture should be demonstrated it would then be advisable to permit a somewhat larger holding than 100 acres, so as to remove any inclination to plant too thickly and thus cause deterioration of the stock.

Doubtless the point will be raised that if the State's planting operations have been less successful than was hoped, the same result will accrue in respect to private undertakings. This does not follow. It is well known that a tenant is usually less careful of the soil than is the owner of a farm, and that a municipality always manages its affairs less efficiently than a private individual or corporation. Abundant experience has shown, as a knowledge of human nature would lead one to predict, that private oyster beds are more carefully and successfully managed than are public ones. They produce more, and the oysters are better. In Mississippi, in 1911, the average price of plants was twice that of oysters from the public beds, and general experience has shown that the better and higher-priced oysters can find a market when the inferior, low-priced stock is begging for a buyer.

Oyster culture consists of more than throwing a lot of oysters or shells on an old reef or tract of barren bottom. The planted material must be properly distributed with due regard to the character of the bottom, and seed oysters must be properly separated from the natural clusters, else they will crowd one another as they grow, many of them will die and the survivors be poor in shape and quality. If through growth and subsequent sets of spat they become too dense on the bottom, they must be judiciously thinned and transplanted, and they must be guarded as much as possible from enemies and from persons taking them illegally. A private planter hoping to reap the reward of his care and industry will see to these things, but the public in dealing with a common property is indifferent, or worse, and the results are unsatisfactory even though the State may spend considerable sums to make it otherwise.

Aside from its production of much-needed foodstuff and its increase in the wealth production of the body politic as a whole, which are the important considerations, oyster culture has the additional advantage of economy in State administration. The care of the public beds is a constant avenue of State outlay. The leasing of barren and naturally unproductive bottom is a source of State revenue.

In all States in which there are natural beds of considerable expanse the major part of the expenditures of oyster-law administration are in their behalf. The production of revenue is not the chief concern when the welfare of industry and the conservation of a food supply

are concerned, but when the people of the State at large are called on to pay the bills, in whole or in part, it is a legitimate and proper subject for consideration.

Finally, the welfare of the public beds and of those obtaining a livelihood from them is not threatened by the encouragement of oyster culture, as with respect to them there need be no change in the policy of the State. If care be taken to exclude the natural beds from leasing, it is probable that they even may be benefited by oyster culture on the barren bottom, and it is reasonably certain that, as has been the case in other parts of the country, a number of those now working on them will become oyster planters if opportunity be given them, thus replacing their present more or less precarious and uncertain livelihood by a more assured and regular as well as more profitable calling.

It is not necessary to discuss in detail the methods of oyster culture, as a special pamphlet[a] on the subject may be obtained on application to the Bureau of Fisheries. It appears advisable, however, to indicate briefly the two general methods open to prospective oyster growers in Mississippi, the planting, or more properly transplanting, of young oysters from the natural or other beds and the deposit of shells or similar materials to which the spat may attach.

As has been shown in the preceding pages, certain of the beds are so densely crowded with small oysters that few of them have chance to develop into marketable stock. Transplanting a considerable number of these from judiciously selected places to barren bottoms should not only result in saving a considerable proportion of the plants but would improve the living conditions of those left on the reefs and permit them therefore to become as good as is possible under their environment. For ordinary cannery purposes the seed oysters would require but rough culling, but if it is desired to produce oysters for shucking or shell stock the clusters should be well broken up, so that the individuals are not at all crowded as they grow. It is not necessary to separate them into single oysters, and where the drumfish is likely to occur it is advisable not to do so. In general, it is desirable to plant seed oysters at least 2 inches long in the more salt water where the drill is found, as those of smaller size and thinner shells are likely to be killed. For the same reason spat setting on the shells rarely survives in drill-infested regions, and the culled seed is not likely to become overgrown with many young. Should oyster culture reach considerable magnitude in the State, or the natural beds become depleted of superfluous young, it will be necessary to resort to shell or other cultch planting to secure a set of spat. This should be conducted in the fresher waters where the drill is least likely to be found, and the material planted, in order to prevent the formation of large clusters, should be in as small pieces as will suffice as collectors.

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[a] Oysters and methods of oyster culture. By H. F. Moore. Bureau of Fisheries Document No. 349.

The section of this report dealing with the barren bottoms, together with the chart, should be consulted for the location of areas on which experiments in oyster culture may be undertaken with some assurance of success. The regions off Deer Island and east of Grand Batture Shoal are probably the most promising. On each of these the depth and the character of the bottom are such that the beds could be worked with light dredges, and both appear to be adapted to the growth of oysters from seed. The work should be conducted as an experiment in the beginning, and not on a scale so large as to entail heavy loss if some of the conditions should unexpectedly prove unfavorable.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS.

The following pages briefly review the conditions developed by the survey, with the deductions and recommendations based on them.

1. The survey included that part of Mississippi Sound lying between the Alabama-Mississippi boundary and Biloxi, being practically restricted to the County of Jackson, although including a small part of Harrison County in the vicinity of Biloxi.

2. Within these limits there are embraced natural beds aggregating about 1,708 acres, of which 475 acres, classed as bearing dense and scattering growth, bear oysters of marketable size in sufficient quantities to support a fishery. On part of this area, however, the quality was too poor at the time of the survey to permit the oysters to find a ready market at a remunerative price. On the remaining 1,233 acres large oysters are too scattered to be taken commercially with profit.

3. It is estimated that in February and March, 1911, these beds contained not less than about 120,000 bushels of oysters over 3 inches long and about 375,000 bushels of smaller ones, a total of not less than 495,000 bushels of oysters of all sizes. Of this quantity, about 80,000 bushels of the larger size and an equal quantity of the smaller ones were on those parts of the beds in which the former were present in sufficient density of growth to warrant a commercial fishery. The bushel measure used was the standard employed in the State, and as the oysters were culled into singles and doubles and compactly arranged, the measure contained a larger number of oysters than is usual in commercial practice. The data furnished is therefore conservative as to the content of the beds.

4. The quantity of small oysters on the beds as a whole is largely in excess of the quantity of large ones, although on the denser areas of market oysters in Biloxi Bay this is not the case. As, however, it requires a larger number of small oysters to produce a given quantity, the small oysters are nearly everywhere numerically equal to or in excess of the large ones, the only exceptions being on some of the

scattering growth areas of Biloxi Bay. On the parts of the beds where the large oysters are most abundant the numerical proportion of small oysters to large ones ranges from equality on the small patches in Biloxi Bay to about 17 to 1 on West Pascagoula Reef. Where the larger oysters are fewer the proportion is generally higher, reaching about 228 to 1 on the so-called depleted part of West Pascagoula Reef, where marketable oysters are practically absent. The young oysters are, therefore, present on practically all of the beds in sufficient numbers to insure the continuance of the present content of market oysters, and the production of some of the beds, especially those in the vicinity of Pascagoula, should be increased by a judicious removal of some of the young.

5. The demand for oysters in Mississippi is in excess of the present supply of good stock. While some of the natural beds in the region east of Biloxi may be improved by rational treatment, it is not believed that they can fill requirements. They may supply some of the demand for cannery purposes, which do not require the highest quality, but they can not satisfactorily fill the demand for the shucking and shell trade.

6. To satisfy this demand for an increased supply, and especially for a better quality than the natural beds produce, the State should enact such legislation as will permit and encourage commercial experiments in oyster culture on the present barren bottoms. There are within the limits of the survey upward of 23,000 acres of bottom, now worthless but apparently suitable in stability and other requirements for oyster culture. These bottoms, if experiment should confirm favorable opinion as to their utility, constitute a valuable asset of the State now wasted for lack of legal authority for their rental. This defect in the oyster laws should be corrected.

7. The Gulf coast in general has advantage over the more northern oyster-producing States in its milder climate, which is less likely to impose interruption to the fishery. It has the disadvantage of affording a somewhat shorter season, owing to the shorter term of cool weather in which oysters can be handled without spoiling. In respect to transportation to a large part of the interior population, it is more favorably situated than are the States of the Atlantic seaboard. It should also have some advantage in the shipment of seed oysters to a considerable part of the Pacific coast.

8. The production of spat is more to be depended on than in the great oyster-producing States of the North, in some of which the set is liable to fail for several years in succession, entailing serious loss on the planters. Moreover, growth is in general more rapid, and marketable oysters are produced in half the time required on some of the northern grounds.

9. Oyster enemies are no more destructive than are those of the North, and some of the worst of the latter do not cause trouble on the Gulf coast. Disaster from freshets is more likely to occur, but can be, to a considerable extent, guarded against by judicious choice of location.

10. One of the most serious difficulties with which planters and oystermen have to contend, the pollution of the public and private beds by drainage and sewage discharges, is minimized by the absence of large communities adjacent to the oyster bottoms. Private beds producing oysters for the market should not be located in proximity to sources of contamination, and floating or "fattening" oysters by immersion in fresh water should be discouraged and absolutely prohibited if the water used be open to suspicion of pollution. The future of the oyster industry everywhere depends in large measure on the guarantee of its product in respect to cleanliness and wholesomeness, and not only the State oyster commissions and boards of health but the oystermen themselves, for both moral and business reasons, should require that the public health be safeguarded from the acts of the careless and unscrupulous.

11. Should a law be passed authorizing the leasing of the barren bottoms, such leaseholds as are granted should be carefully surveyed to determine their areas, the tracts should be regular in shape, and the corners located by reference to the triangulation stations or landmarks established by the Coast and Geodetic Survey. These are all carefully determined and are permanently marked, and a strict compliance with this recommendation will guarantee accuracy in the surveys, obviate disputes, and secure an honest and correct assessment of rental.

12. Legislation to secure these ends should be carefully drawn and based on the experience of States in which oyster planting has been successful from the standpoints of the planters and the State as a whole.

O

OYSTERS FROM SCRANTON REEF.

(Natural size.)

OYSTERS FROM WEST PASCAGOULA REEF.

(Natural size.)

OYSTER FROM DEER ISLAND BED, BILOXI BAY.

(Natural size.)

OYSTERS FROM SMALL PATCH, BILOXI BAY.

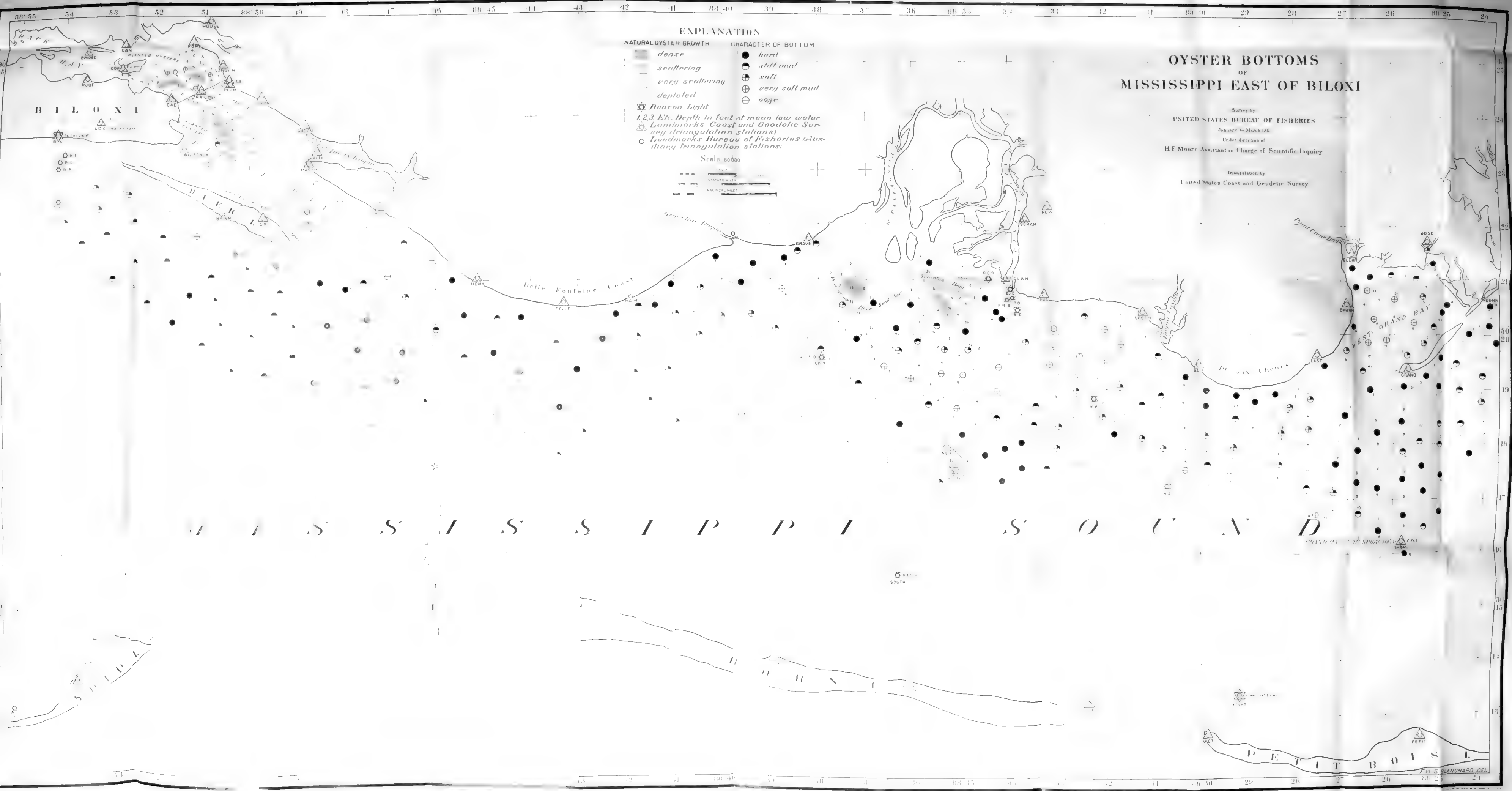
(Natural size.)

OYSTERS FROM LARGE BED, BILOXI BAY.

(Natural size.)

OYSTERS FROM BACK BAY, BILOXI.

(Natural size.)



OYSTER BOTTOMS
OF
MISSISSIPPI EAST OF BILOXI
Survey by
UNITED STATES BUREAU OF FISHERIES
January to March 1911
Under direction of
H F Moore Assistant in Charge of Scientific Inquiry
Triangulation by
United States Coast and Geodetic Survey
EXPLANATION
NATURAL OYSTER GROWTH
dense
scattering
very scattering
depleted
CHARACTER OF BOTTOM
hard
stiff mud
soft
very soft mud
ooze
Beacon Light
1,2,3, Etc. Depth in feet at mean low water
Landmarks Coast and Geodetic Survey (triangulation stations)
Landmarks Bureau of Fisheries (Auxiliary triangulation stations)
Scale 1/60000
STATUTE MILES
NAUTICAL MILES
BILOXI
BACK BAY
DEER I.
Belle Fontaine Coast
MISSISSIPPI SOUND
WEST GRAND BAY
PETIT BOIS I.
HORN I.
F. W. S. BLANCHARD DEL.